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CONODONT DISTRIBUTION IN FACIES OF THE STANTON FORMATION (UPPER PENNSYLVANIAN, MISSOURIAN) IN SOUTHEASTERN KANSAS

by

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A thesis submitted in partial fulfillment of the
requirements for the degree of Master of
Science in the Department of Geology
in the Graduate College of
The University of Iowa

May 1977

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CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's thesis of

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has been approved by the Examining Committee for the thesis requirement for the Master of Science degree in the Department of Geology at the December 1976 graduation.

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ACKNOWLEDGMENTS

Several people have helped me in the completion of this thesis. The project was suggested by Dr. Philip H. Heckel who has assisted me throughout as my thesis supervisor. Dr. Gilbert Klapper and John Swade helped to confirm the identification of the conodont species recovered. Thanks also to Dr. William Furnish and Dr. Gilbert Klapper for serving on the thesis committee. Each provided valuable suggestions toward its completion.

The Kansas Geological Survey provided funds to help defray field expenses and assisted with maps and publications.

A special thanks to all of the landowners who allowed me to collect samples on their property. Their co-operation is appreciated.

ABSTRACT

Detailed study of conodont distribution laterally within all members of the Stanton cyclothem (nearshore shale, transgressive limestone, offshore shale, regressive limestone, nearshore shale) shows that the vertical change established for the entire cyclic Missourian sequence still far outweighs lateral change. Basic patterns include: 1) *Idiognathodus* spp. are nearly ubiquitous, increasing greatly in numbers from nearshore shales into the offshore shale. 2) *Anchignathodus minutus* increases through the limestone members toward the offshore shale, but decreases into some gray shales and is not present in most of the black shale samples. 3) Disaggregation of the black anoxic facies of the offshore shale yielded *Idiognathodus* spp., *Anchignathodus*? sp. A, *Idioprioniodus typus*, and *Gondolella bella*, all of which probably were pelagic. 4) *A*. sp. A, *I*. *typus*, and *G*. *bella* are confined to the offshore shale and adjacent portions of the two limestone members, thus seem much more closely related to the deeper water phase of deposition during maximum transgression than to specific bottom environments. 5) *Adetognathus* spp. are scattered sparsely throughout the cyclothem, tending to occur in

higher numbers in samples associated with oolites and channel flanks, but were not recovered from most of the black shale samples. 6) Aethotaxis advena and Stepanovites conflexa are rare and were possibly controlled somewhat by lithologic association. 7) Depth zonation is reflected by two groupings of species: a) Adetognathus spp., Idiognathodus spp., Anchignathodus minutus, Aethotaxis advena, and Stepanovites conflexa, settled into waters of all depths; whereas b) Anchignathodus? sp. A, Idioprioniodus typus, and Gondolella bella, are species confined to deeper water sediments.

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INTRODUCTION

Recent work on Pennsylvanian conodonts has established certain aspects of their distribution, multielement taxonomy, and probable ecology (e.g. Von Bitter, 1972, 1976; Merrill, 1973, 1975; Baesemann, 1973; Merrill and Von Bitter, 1976). Analysis of Baesemann's data combined with interpretation of the cyclic lithologic sequence, has led to establishment of an ecologic model that explains distribution of Missourian conodonts in eastern Kansas (Heckel and Baesemann, 1975). It is based on the model of Seddon and Sweet (1971), which assumes that most conodonts were pelagic and that different species were subject to vertical depth stratification. Their model was illustrated by the analyses of certain Ordovician and Devonian conodont faunas along traverses going offshore in the direction of deeper water, and showing that the diversity of the conodonts increases in an additive fashion with depth.

Geologic Setting

The Stanton Formation is one of the best exposed of several predominantly carbonate formations in the Missourian Stage of eastern Kansas (Figure 1) that are considered to represent major marine transgressive-regressive sequences by Heckel and Baesemann (1975). Because of this, intensive investigation of many aspects of the Stanton Formation in eastern Kansas has been undertaken. Specific studies relate to depositional environment (Heckel, 1972a,b), stratigraphy and lithology (Heckel, 1975a), macrofauna (Senich, 1975; in prep.), and microfauna (M. D. Brondos, in prep.).

The Stanton Formation crops out generally north to south in eastern Kansas (Figure 2). In northeastern Kansas, it is characterized by a laterally uniform sequence of open-marine limestones and shales that defines the open marine facies belt (Heckel, 1975b). This sequence consists of three carbonate units (Captain Creek, Stoner, South Bend) that are separated by two thin shales (Eudora, Rock Lake) (Figure 3). Each of the members is distinctive enough to be delineated easily and traced laterally (Heckel, 1975a).

In southeastern Kansas, the three carbonate members of the Stanton Formation thicken into phylloid algal mound complexes (Heckel and Cocke, 1969) that define the phylloid algal mound facies belt (Figure 2). In this area, the two shale members are less easily located, making delineation and lateral tracing of members in the Stanton Formation more difficult. However, in Montgomery County the thickened carbonate members of the Stanton Formation thin drastically and eventually disappear. At this point, the two intervening shale members (Rock Lake, Eudora) become very thick and define the terrigenous detrital facies belt (Figure 2). The stratigraphic, lithologic, and geographic relationships of these facies have been described by Heckel and Cocke (1969) and Heckel (1972a, b; 1975a, b).

The mound sequence consists of buildups composed of phylloid algal calcilutite with a "rim" along the northwest side composed of calcarenite (Figure 4). The buildups are cut by contemporaneous channels filled with skeletal calcarenite and calcilutite, black shale, gray shale, conglomerate, and sandstone. Presently the topographic expression at equivalent stratigraphic horizons between the channels and the mounds involves about eighty feet (twenty-five meters) of relief (Heckel, 1972a, b; 1975b). Mound facies grade abruptly southward across the Elk River valley in Montgomery County (Figure 5) into a thick sequence of terrigenous detrital rocks (Figure 6) largely calcareous to silty shale and sandstone, and including thin layers of sponge-rich calcilutite, skeletal calcarenite and oolite. The terrigenous detrital rocks include marine to nearshore and shoreline facies that extend southward into Oklahoma.

In the Pennsylvanian of eastern Kansas, a cyclothem is is now defined by Heckel (1977) as a single transgressive-regressive sequence consisting of limestone and shale members in the following ascending order: outside (near-shore) shale -- middle (transgressive) limestone -- core (offshore) shale -- upper (regressive) limestone -- outside (nearshore) shale. The core (offshore) shale represents the maximum transgression and is normally marked by a phosphatic black shale facies. The Stanton Formation, together with the overlying and underlying shale units, is considered to represent two more or less complete cyclothem sequences. The lower or Stanton cyclothem consists of; Vilas = outside shale, Captain Creek = middle limestone, Eudora = core shale, Stoner = upper limestone, Rock Lake = outside shale. Above the Stanton cyclothem lies the incomplete South Bend cyclothem which consists of: Rock Lake = outside shale, South Bend = middle limestone, Weston = core shale at the base grading upward to outside shale with no development of a regressive limestone member, probably due to overwhelming detrital influx (P. H. Heckel, personal communication, 1976).

Purpose and Scope

While knowledge of conodont distribution in the Stanton Formation was available for northeastern Kansas (Baesemann, 1973), conodont distributions had not been studied in the more complex facies region of southeastern Kansas. The purpose of this paper is to study the distribution of conodonts in the various lithologies associated with algal-mound, channel, offmound carbonate and shale facies in the Stanton Formation in southeastern Kansas. If the model of Heckel and Baesemann (1975) can be applied throughout the Stanton Formation, the geographic pattern of conodont distribution should relate to lateral depth variation delineated in the facies and environments by Heckel (1972; 1975a, b), and the vertical variation in conodont distribution should relate to changes in water depth resulting from transgression and regression of the sea, which was responsible for the Stanton cyclothem (Heckel and Baesemann, 1975; Heckel, 1975b). Factors controlling conodont distribution more likely were those such as light penetration, temperature, oxygenation, and salinity that vary generally with water depth, rather than water depth (i.e. pressure) alone (Heckel and Baesemann, 1975, p. 504-505).

Field Methods

A total of 138 samples, collected at 24 localities (Figures 4, 5) (Appendix A, B) along the Stanton outcrop were processed for conodonts. These samples and localities were selected to be representative of lithic variation within the Stanton Formation throughout the three major facies belts (Figure 2) and the various subdivisions (channel, mound, rim) of the algal mound facies belt (Figures 4, 5). Representative samples of all of the members and beds within the Stanton Formation were processed for conodonts except for the Onion Creek sandstone body in the Rock Lake Shale Member in central Montgomery County (Figure 6).

Laboratory Methods

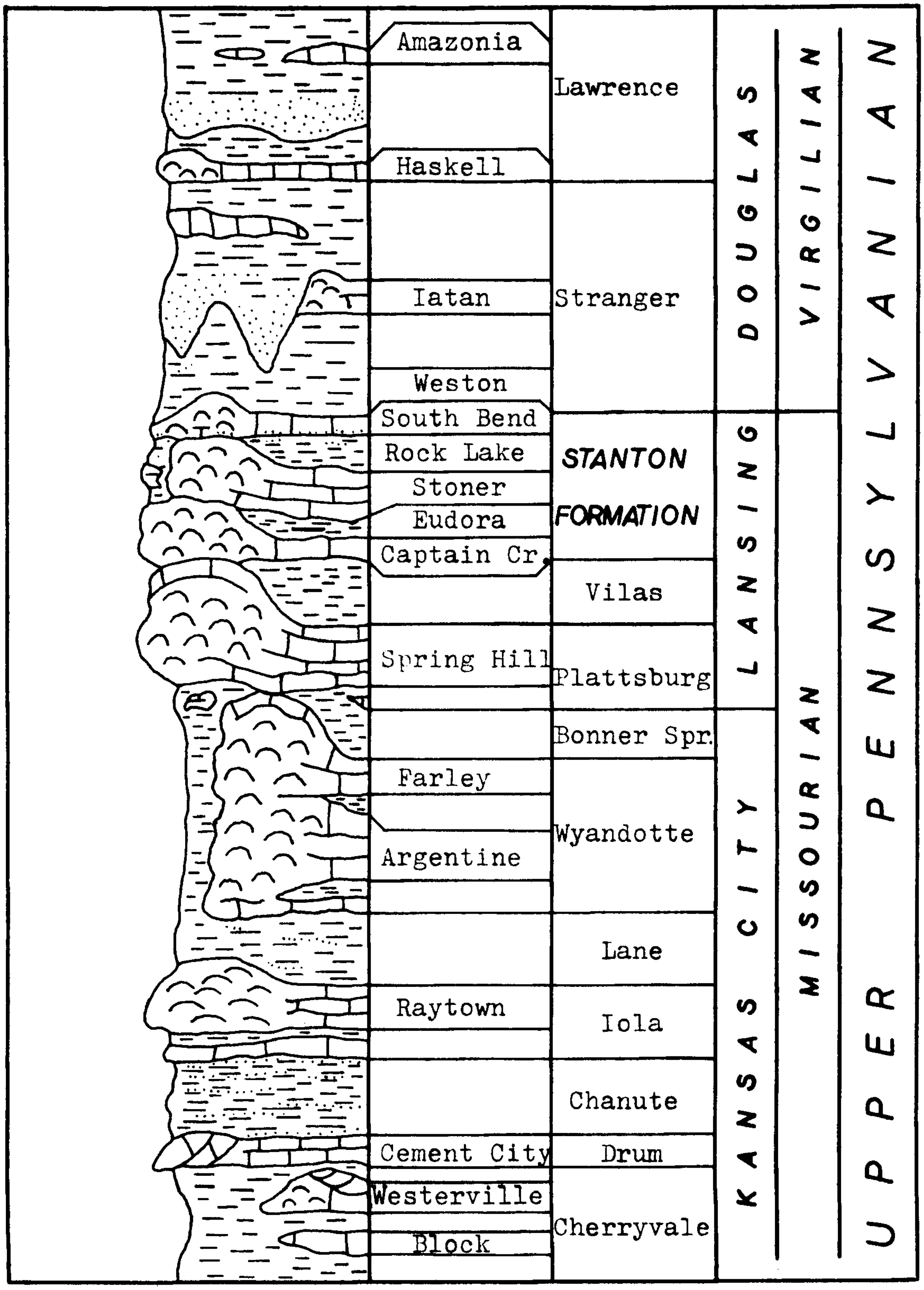
A standard sample size of one kilogram was processed for conodonts except for two samples collected at locality 19, where samples of two kilograms were processed. The process used to break down the carbonate samples involved 24 hours in a 10% solution of formic acid. The gray shales were disaggregated by heating until dry, immersion for one hour in Stoddard solvent, and then three to four days in water.

The technique used to break down the platy black shales usually takes between three and five weeks. It involves soaking them in 5% sodium hypochlorite for three to four days, then soaking them in water for three to four days with a careful screening out of the 125 micron size particles between each step. This sequence is then repeated until the shale will not break down any further.

The screens used in processing all of the samples were 840 micron on top, 125 micron in the middle, and 90 micron on the bottom. The residue collected on the 125 micron screen in each sample was thoroughly picked for conodonts; occasionally, the residue from the 90 micron screen was also picked. Heavy liquid separation (using tetrabromoethane) was necessary with large residues, including many from the carbonate samples, most of the gray shales, and all of the black shales. Identification of fragments and extremely small conodonts was not attempted unless at least a confident identification could be accomplished. However, more diligent attempts were made to identify fragments from the sparser samples. More than 21,000 conodonts were collected and identified from the 138 samples that were processed for this study.

Lithologies of all samples that were processed for conodonts were studied in order to determine relations between rock type and condont distribution. Polished sections of the carbonate samples were prepared and studied microscopically. The insoluble residues of the carbonates and shales were similarly studied, as were the bedding surfaces of the black shales. Thin sections of the carbonate samples were not prepared for this study because of previous work by Heckel and Cocke (1969), Heckel (1972b; 1975a), and Senich (1975).

Figure 1--Generalized stratigraphic column of part of Upper Pennsylvanian section in eastern Kansas (modified after Heckel and Cocke, 1969, Figure 1).



Amazonia
Lawrence
Haskell
Iatan
Stranger
Weston
South Bend
Rock Lake
STANTON FORMATION
Stoner
Eudora
Captain Cr.
Vilas
Spring Hill
Plattsburg
Bonner Spr.
Farley
Wyandotte
Argentine
Lane
Raytown
Iola
Chanute
Cement City
Drum
Westerville
Cherryvale
Block
DOUGLAS
LANSING
KANSAS CITY
VIRGILIAN
MISSOURIAN
UPPER PENNSYLVANIAN

Figure 1

Figure 2--Generalized Missourian outcrop belt (lined) with Stanton Formation (solid black) in eastern Kansas showing locations of: Baesemann's 1973 collected Stanton section (A), collected sections 1a and 1b, for this study (B), section C on Figure 3, and three facies belts (adapted from Heckel and Baesemann, 1975, Figure 3).

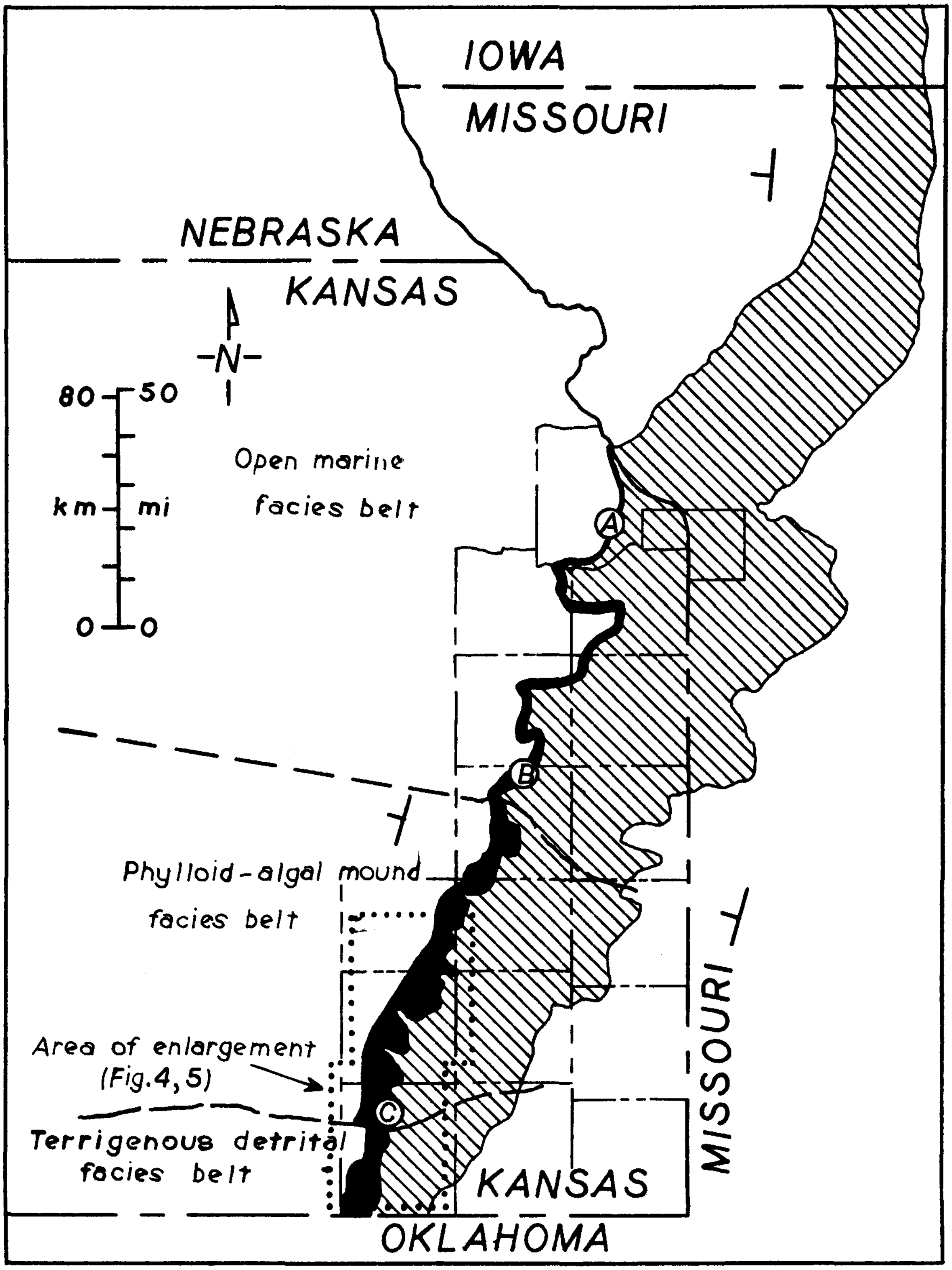

IOWA
MISSOURI
NEBRASKA
KANSAS
N
80
50
km
mi
0
0
Open marine
facies belt
A
B
Phylloid-algal mound
facies belt
Area of enlargement
(Fig.4,5)
C
Terrigenous detrital
facies belt
MISSOURI
KANSAS
OKLAHOMA

Figure 2

Figure 3--Measured sections (located on Figure 2) of Stanton Limestone in eastern Kansas showing subdivisions into five named members recognized throughout phylloid-algal mound and open marine facies belts (after Heckel, 1975a, Figure 3).

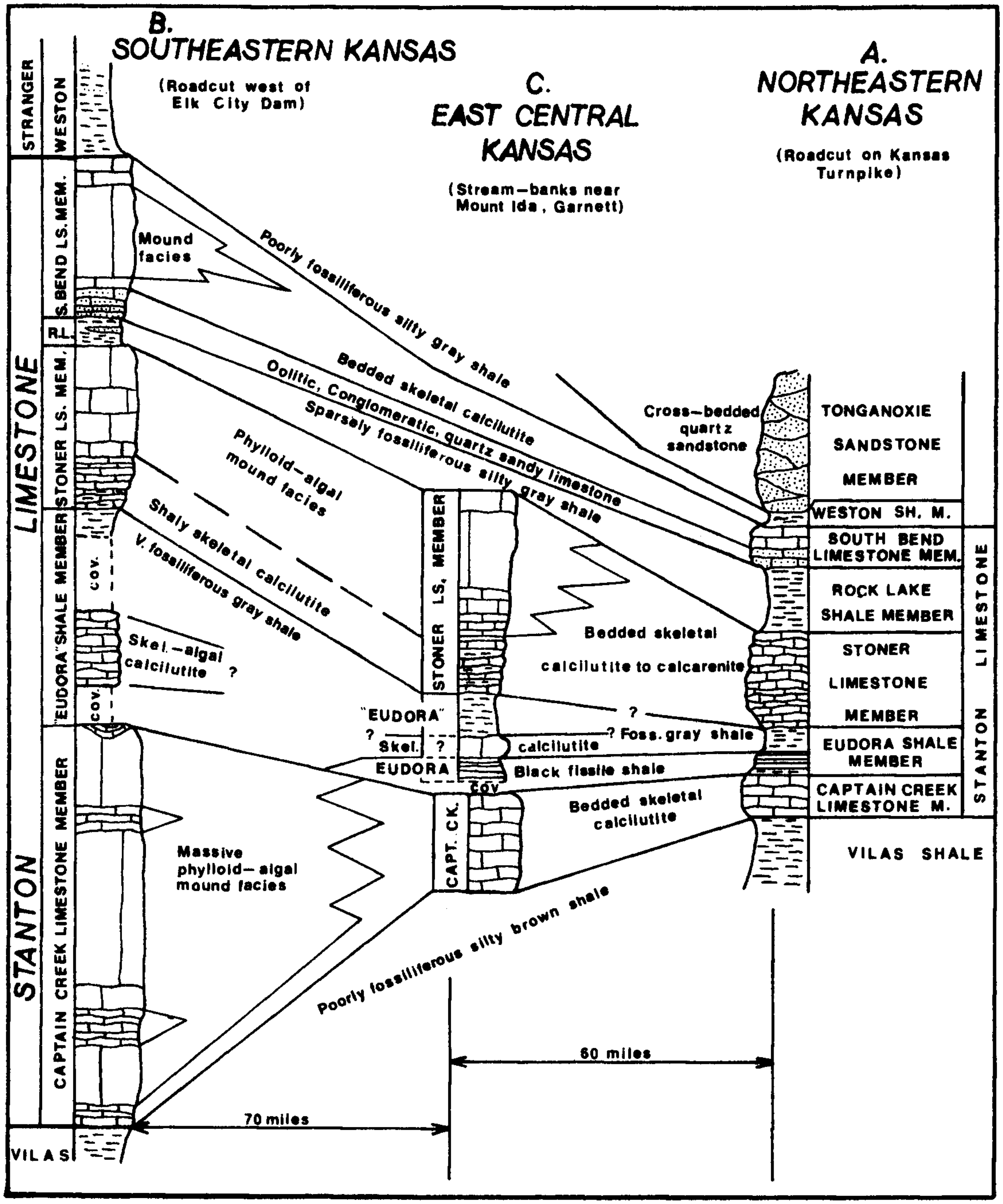

B.
SOUTHEASTERN KANSAS
(Roadcut west of Elk City Dam)
C.
EAST CENTRAL KANSAS
(Stream-banks near Mount Ida, Garnett)
A.
NORTHEASTERN KANSAS
(Roadcut on Kansas Turnpike)
STRANGER
WESTON
LIMESTONE
STANTON
S. BEND LS. MEM.
R.L.
STONER LS. MEM.
"EUDORA" SHALE MEMBER
CAPTAIN CREEK LIMESTONE MEMBER
VILAS
Mound facies
Poorly fossiliferous silty gray shale
Bedded skeletal calcilutite
Oolitic, Conglomeratic, quartz sandy limestone
Sparsely fossiliferous silty gray shale
Phylloid-algal mound facies
Shaly skeletal calcilutite
V. fossiliferous gray shale
Skel.-algal calcilutite ?
COV.
Cross-bedded quartz sandstone
TONGANOXIE SANDSTONE MEMBER
WESTON SH. M.
SOUTH BEND LIMESTONE MEM.
ROCK LAKE SHALE MEMBER
STONER LIMESTONE MEMBER
EUDORA SHALE MEMBER
CAPTAIN CREEK LIMESTONE M.
VILAS SHALE
STANTON LIMESTONE
STONER LS. MEMBER
Bedded skeletal calcilutite to calcarenite
"EUDORA"
Skel.
calcilutite
? Foss. gray shale
EUDORA
Black fissile shale
COV
CAPT. CK.
Bedded skeletal calcilutite
Massive phylloid-algal mound facies
Poorly fossiliferous silty brown shale
60 miles
70 miles

Figure 3

Figure 4--Northern part of outcrop and facies regions of Stanton Formation in southeastern Kansas, showing approximate locations of collected localities 2 - 12; exact locations of collecting localities found in Appendix B (after Heckel, 1975b, Figure 8). The following symbols are used: SB - South Bend Limestone Member, CC - base of Captain Creek Limestone Member, and + - township corner.

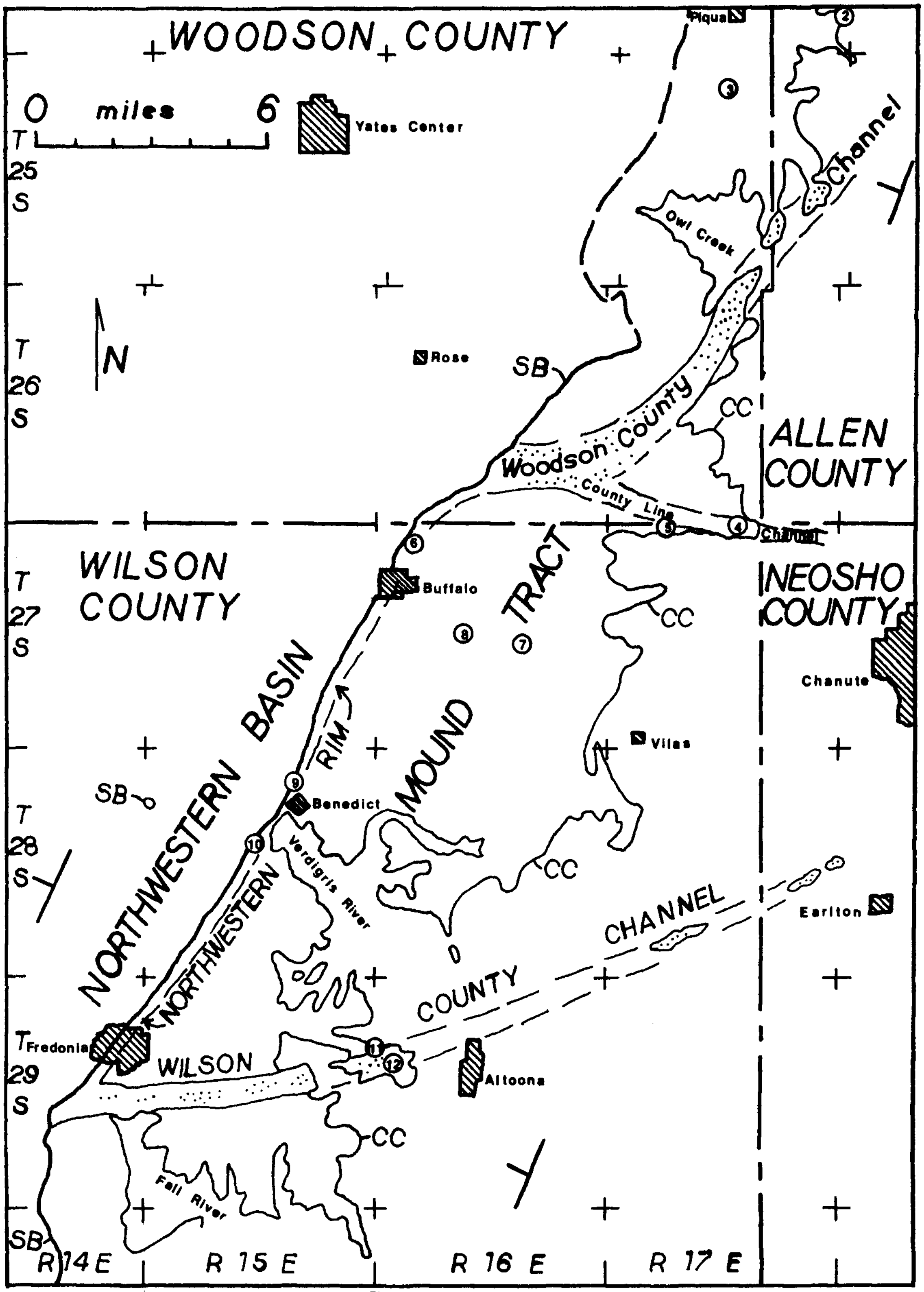
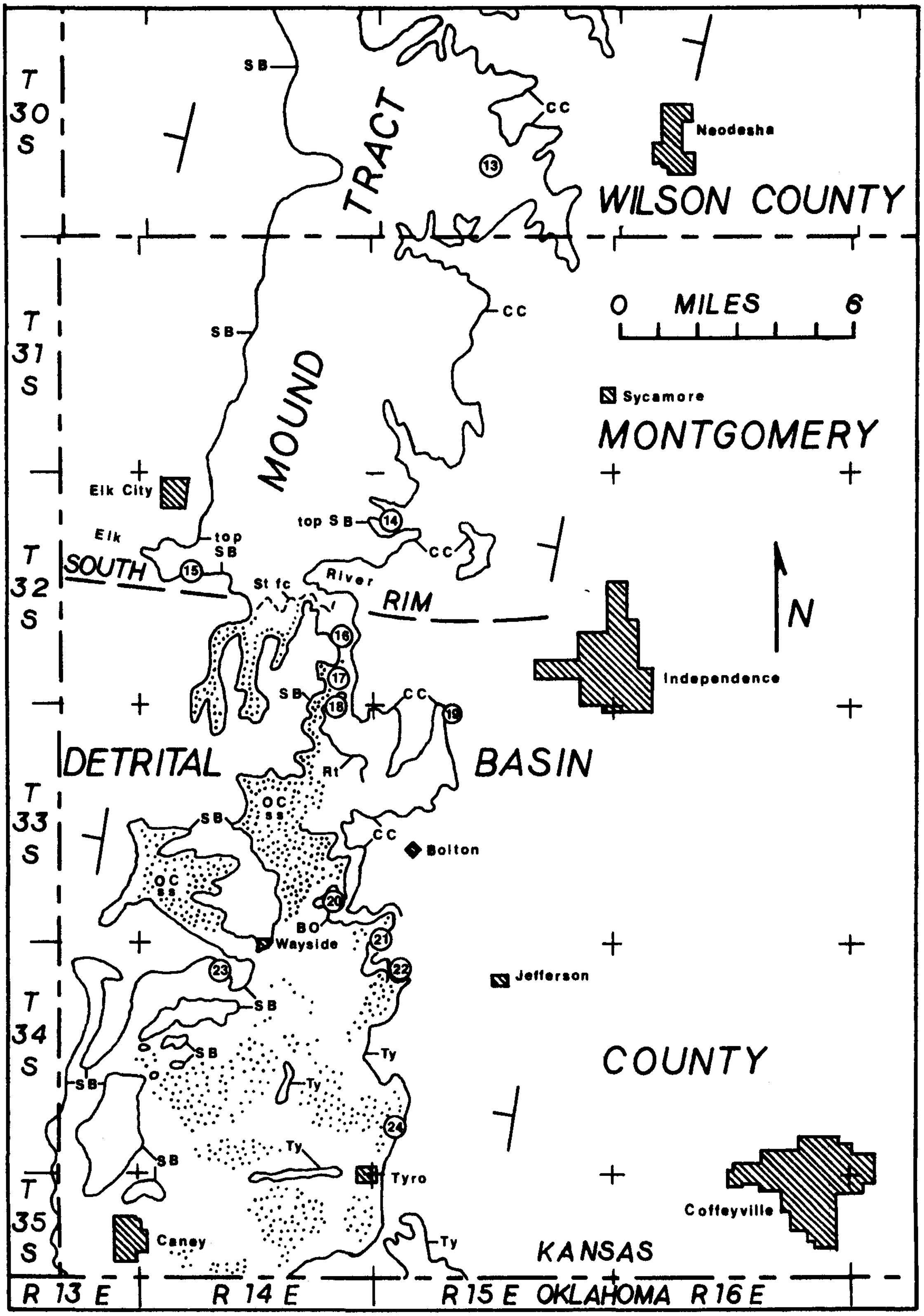

WOODSON COUNTY
0 miles 6
Yates Center
Piqua
Channel
Owl Creek
Rose
SB
Woodson County
County Line
CC
ALLEN COUNTY
Chanute
WILSON COUNTY
NEOSHO COUNTY
Buffalo
TRACT
MOUND
RIM
NORTHWESTERN BASIN
NORTHWESTERN
Benedict
Vilas
Verdigris River
CHANNEL
COUNTY
WILSON
Earlton
Fredonia
Altoona
Fall River
N
T 25 S
T 26 S
T 27 S
T 28 S
T 29 S
R 14 E
R 15 E
R 16 E
R 17 E
Figure 4

Figure 5--Southern continuation of figure 4 showing approximate locations of collected localities 13 - 24; exact locations found in Appendix B (after Heckel, 1975b, Figure 8). The following symbols are used: SB - South Bend Limestone Member, OCSS - Onion Creek Sandstone body, Rt - Rutland Bed, Bo - Bolton Bed, Stfc - Stoner Limestone Member facies change, CC - base of Captain Creek Limestone Member, Ty - Tyro Oolite Bed, and + - township corner.



T 30 S
T 31 S
T 32 S
T 33 S
T 34 S
T 35 S
SB
TRACT
MOUND
cc
Neodesha
13
WILSON COUNTY
0 MILES 6
Sycamore
MONTGOMERY
Elk City
top SB
14
Elk
top SB
SOUTH
15
St fc
River
RIM
16
17
18
19
N
Independence
DETRITAL
BASIN
Rt
OC ss
Bolton
20
BO
Wayside
21
22
23
Jefferson
Ty
COUNTY
24
Tyro
Coffeyville
Caney
KANSAS
R 13 E
R 14 E
R 15 E
OKLAHOMA
R 16 E

Figure 5

Figure 6—Generalized cross section showing subdivisions and facies of Stanton Formation across terrigenous detrital facies belt (Figure 2) in Montgomery County with collected localities (modified after Heckel, 1975a, Figure 4).

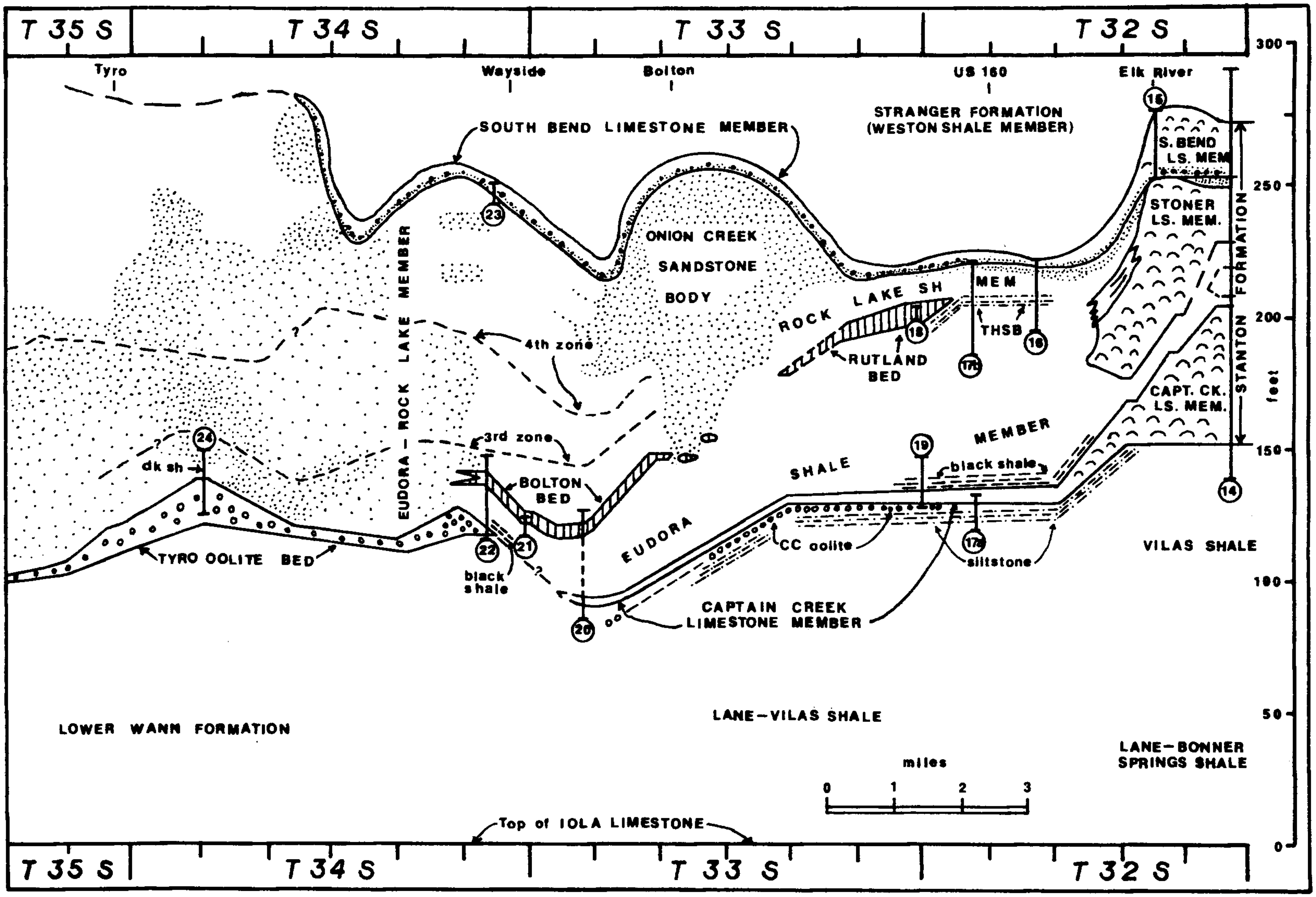

T 35 S
T 34 S
T 33 S
T 32 S
Tyro
Wayside
Bolton
US 160
Elk River
STRANGER FORMATION
(WESTON SHALE MEMBER)
SOUTH BEND LIMESTONE MEMBER
S. BEND
LS. MEM.
STONER
LS. MEM.
ONION CREEK
SANDSTONE
BODY
ROCK LAKE SH MEM
RUTLAND
BED
THSB
EUDORA – ROCK LAKE MEMBER
4th zone
3rd zone
dk sh
BOLTON
BED
black
shale
TYRO OOLITE BED
EUDORA SHALE MEMBER
black shale
CC oolite
siltstone
CAPT. CK.
LS. MEM.
STANTON FORMATION
CAPTAIN CREEK
LIMESTONE MEMBER
VILAS SHALE
LOWER WANN FORMATION
LANE–VILAS SHALE
LANE–BONNER
SPRINGS SHALE
miles
0
1
2
3
Top of IOLA LIMESTONE
feet
300
250
200
150
100
50
0

Figure 6

CONODONT DISTRIBUTION IN MEMBERS OF THE STANTON FORMATION AND ADJACENT UNITS

In order to categorize conodont abundance, a frequency graph was constructed using total conodont element abundance for each of the conodont genera in each sample. The following terms will be applied to each abundance category defined by natural breaks in abundance on the frequency graph; absent = 0, rare = 1 - 9, frequent = 10 - 30, common = 31 - 100, abundant = 101 - 500, and very abundant = 500+.

Vilas Shale

The Vilas Shale, considered to be an outside shale in the cyclothem (Heckel, 1975b), underlies the Stanton Limestone in southeastern Kansas. No conodonts were recovered from any of the three samples processed north of Montgomery County. At Locality 14 (RC), the northernmost sample of Vilas Shale collected in Montgomery County, *Adetognathus* spp. are rare, and is the only conodont genus recovered from the sample. In the next sample of Vilas Shale collected 3.5 miles to the south at Locality 17a (EUS160RC), *Adetognathus lautus*, *Idiognathodus elegantulus*, and *Anchignathodus* spp. are rare. In the sample collected east of Locality 17a at Locality 19 (WM), Idiognathodus elegantulus is rare and the only conodont recovered. At Locality 20 (#27), the southernmost sample of Vilas Shale collected, Anchignathodus minutus is rare and Idiognathodus elegantulus is frequent. Even though conodont abundance is low in the seven samples that were processed from the top of the Vilas Shale, a general increase in condont abundance and diversity to the south is suggested, with replacement of Adetognathus spp. by Idiognathodus spp. in dominance.

Benedict Bed

The Benedict bed and overlying shale are present at the base of the Captain Creek Limestone in two localities collected in Wilson and Allen Counties. At Locality 2 (US54RC), toward the north, the Benedict bed consists of stromatolite heads that are surrounded by shale. Here, Adetognathus spp., Idiognathodus spp., Stepanovites conflexa, and Anchignathodus minutus are rare in the stromatolite; in the top of the overlying shale, Adetognathus spp. are rare and represent the only conodont genus recovered. At Locality 9 (TSBB), the Benedict bed consists of 4.5 ft. of skeletal oolite and is overlain by 2.5 ft. of shale. At this locality, Adetognathus spp. are frequent and represent the only conodont genus recovered at the base of the Benedict bed; in the top of the

Benedict bed and base of overlying shale, *Adetognathus* spp. and *Idiognathodus* spp. are rare. No conodonts were recovered from the top of the shale at Locality 19 (TSBB). Although numbers are low, *Adetognathus* spp. dominate the samples processed from the Benedict bed and represent the only conodont genus recovered in two of the five samples that yielded conodonts in this unit.

Captain Creek Limestone Member

The Captain Creek Limestone Member is considered to be the middle limestone member in the cyclothem, and it forms the base of the Stanton Formation except locally where the Benedict bed is present. It is characterized by a gradual overall thinning north of Locality 14 (RC) and a rapid thinning southward. Its southern limit is near Locality 20 (#27), south of which the Tyro oolite forms the base of the Stanton Formation (Heckel, 1975a, b). In the samples of Captain Creek collected in the open marine facies belt (Locality 1, PTC), *Adetognathus* spp. are rare and scattered throughout the samples, and *Anchignathodus minutus* and *Idiognathodus elegantulus* are present only in the middle and top. In the samples of Captain Creek collected in the phylloid-algal mound facies belt (Localities 2 - 5, 7, 9, 11, 12, 14), *Adetognathus* spp., *A. minutus*, and *I. elegantulus* are generally scattered throughout the samples. *Idiognathodus delicatus*, Gondolella bella, and Idioprioniodus typus occur only in the top at Localities 3, 5, 7, and 12, and Idiognathodus sp. A, Anchignathodus? sp. A, and Stepanovites conflexa are rare and present only at the top at one locality each (Localities 3, 5, and 7 respectively). In the samples of Captain Creek collected in the terrigenous detrital facies belt (Localities 17, 19, 20); I. elegantulus and A. minutus are generally scattered throughout the samples. Adetognathus spp. and Aethotaxis advena occur mainly in the base, and I. delicatus is present only in the base at locality 20 (#27). In general, conodont species tend to increase in number and diversity upward in the Captain Creek Limestone, with maximum numbers and diversity in the phylloid-algal mound facies belt at the top of the Captain Creek Limestone, where a phosphatic shale directly overlies it.

Tyro Oolite Bed

The Tyro oolite bed appears south of the southernmost known exposures of the Captain Creek in the terrigenous detrital facies belt, where it forms the base of the Stanton Formation (Heckel, 1975b). In the northernmost exposure collected at Locality 22 (RCWHWJ), Adetognathus spp. and Idiognathodus spp. are rare in the upper Tyro oolite. Two samples were processed in the Tyro oolite at Locality 24 (TyQu): Anchignathodus minutus, Adetognathus spp. and I. elegantulus are rare in the sample of middle

Tyro oolite, and at the top of the Tyro oolite, *Adetognathus* spp. and *A. minutus* are rare, and *I. elegantulus* is frequent. In general, *Adetognathus* spp. and *I. elegantulus* appear to dominate the Tyro oolite; however, only three samples were processed from this unit, and conodont abundance is low.

Eudora Shale Member

The Eudora Shale Member is generally present above the Captain Creek Limestone and Tyro oolite in eastern Kansas, and it is considered to be the core shale in the cyclothem (Heckel, 1975b). *Anchignathodus minutus*, *Adetognathus* spp., and *Stepanovites conflexa* occur mainly in low numbers and are generally scattered throughout the Eudora Shale (Localities 1, 3, 4, 5, 7, 12). They are present in low numbers in dark gray to black shale samples that lack phosphate (Localities 12, 24) but do not occur in the fissile phosphatic black facies (Localities 1, 4, 19, 22); in the terrigenous detrital facies belt (Localities 16, 17, 19, 21, 22, 24) they are found mainly near the base, and *S. conflexa* was recovered only in samples from Locality 19 (WM). *Anchignathodus*? sp. A occurs primarily in and immediately above and below the fissile phosphatic black facies of the Eudora Shale (Localities 1, 4, 12, 22). *Idioprioniodus typus*, *Gondolella bella*, and the three species of *Idiognathodus* recognized in this study occur in highest numbers generally throughout the Eudora Shale including the black facies, in the open marine and phylloid-algal mound facies belts (Localities 1, 3, 4, 5, 7, 12). In the terrigenous detrital facies belt (Localities 16, 17, 19, 21, 22, 24), these conodonts generally occur in lower numbers and are concentrated mainly in the black facies. *I. delicatus* extends to the top of the Eudora Shale at some localities (21, 22), and *I. elegantulus* tends to occur mainly below the black shale facies (Localities 19, 22, 24). In general, except for the absence of *Aethotaxis advena*, samples of Eudora Shale from the open marine and phylloid-algal mound facies belts contain the maximum diversity of conodonts and the highest concentrations of *G. bella*, *I. typus*, *S. conflexa*, *Anchignathodus*? sp. A, and *Idiognathodus* spp.

Stoner Limestone Member

The Stoner Limestone Member lies above the Eudora Shale, and it is considered to be an upper limestone member of the cyclothem (Heckel, 1975b). *Stepanovites conflexa*, *Idioprioniodus typus*, and *Gondolella bella* are rare and found only in the base of the Stoner Limestone in the open marine facies belt (Locality 1). *Aethotaxis advena* is rare in the middle. *Idiognathodus* sp. A is rare in the middle and upper parts. *Idiognathodus delicatus* and

Anchignathodus minutus are rare throughout with I. delicatus frequent in the base.

The Stoner Limestone thickens southward in the phylloid-algal mound facies belt ending at the northern limit of the terrigenous detrital facies belt (Heckel, 1975a, b). The samples processed in the base of the Stoner Limestone (Localities 3, 5, 7, 11, 12, 14) here are generally muddy whole-shell skeletal calcarenite with interbedded shale grading upward to skeletal calcilutite. I. elegantulus, G. bella, and I. typus are mainly in the base of the Stoner Limestone (Localities 3, 5, 7, 11, 12, 14), tending to increase in numbers from rare to abundant toward the Wilson County Channel, where they occur in maximum numbers (Locality 12, ARC). In the samples collected at Locality 10 (BB) in the mound flank, G. bella occurs stratigraphically higher in the Stoner Limestone than anywhere else. S. conflexa (Localities 3, 5, 7, 12) and Anchignathodus? sp. A (Localities 5, 7, 11, 12) are generally rare and A. advena is rare and present only at Locality 12 (ARC) in the base of the Stoner Limestone. Adetognathus spp., A. minutus, and I. delicatus are generally present in low numbers scattered throughout the Stoner Limestone (Localities 3 - 8, 10 - 14). A. minutus and I. delicatus are more abundant in samples collected at the base. Here I. delicatus generally increases from common southward to abundant at Locality 12 (ARC). The general trend observed in the Stoner Limestone is that conodont abundance and diversity generally increase downward in the phylloid-algal mound facies belt, where maximum diversity and highest numbers occur at the base.

Bolton Limestone Bed

The Bolton limestone bed crops out in the central four miles of the terrigenous detrital facies belt in Montgomery County. It lies between the Eudora and Rock Lake Shales and is probably equivalent to the lower part of the Stoner Limestone Member (Heckel, 1975b). *Adetognathus* spp. and *Idiognathodus delicatus* are rare to frequent throughout the Bolton bed, and *Adetognathus* spp. increases in dominance upward. *Idiognathodus* sp. A, *Idiognathodus elegantulus* and *Gondolella bella* are rare at the base and top of the Bolton bed, with *I. elegantulus* increasing slightly in number to the southeast (Localities 21, 22) where it is joined by *Idioprioniodus typus* and *G. bella* in the base. *Stepanovites conflexa* is rare and occurs only in the middle sample of the Bolton Bed at Locality 20 (#27). In general, even though conodont abundance is low, all of the species studied are present in the Bolton bed except *Anchignathodus* spp. and *Aethotaxis advena*. *Idiognathodus* spp. and *Adetognathus* spp. generally tend to dominate in the samples processed.

Rutland Limestone Bed

The Rutland limestone bed crops out only in the northern terrigenous detrital facies belt. It lies above the Eudora Shale and Timber Hill siltstone bed and below the Rock Lake Shale, and it is considered to be equivalent to the top of the Stoner Limestone (Heckel, 1975b). At Locality 18 (RB), in the sample processed from the middle of the Rutland bed, Stepanovites conflexa and Adetognathus spp. are rare. No conodonts were recovered in the top of the Rutland bed.

Rock Lake Shale Member

The Rock Lake Shale Member overlies the Stoner Limestone Member and the Rutland and Bolton beds where present. It is considered to be an outside shale separating the Stanton and South Bend cyclothems (P.H. Heckel, personal communication, 1976). In the phylloid-algal mound facies belt (Localities 14, 16, 17), Idiognathodus delicatus is rare and in only one sample at the base of the Rock Lake Shale. Idiognathodus sp. A is rare in the base and top at one locality each. In the terrigenous detrital facies belt, only the samples of Rock Lake Shale collected at Locality 20 (#27) yielded conodonts. Here Adetognathus spp. is frequent at the base and rare at the top, Idiognathodus sp. A is rare, and Idiognathodus elegantulus is rare and present only at the top. The general trends observed in the Rock Lake Shale are: 1) conodonts are rare everywhere, 2) *Idiognathodus* is the only conodont present in the north and *Adetognathus* joins *Idiognathodus* in the south.

South Bend Limestone Member

Although forming the top of the Stanton Formation as a lithologic unit, the South Bend Limestone Member is considered to represent the middle limestone member of a younger cyclothem (Heckel, 1975b). *Adetognathus* spp., *Idiognathodus* sp. A, *I. delicatus*, and *I. elegantulus* are rare in the sample processed in the lower South Bend Limestone (Locality 12, ARC). *Adetognathus* spp. and *Anchignathodus*? sp. A are rare, occurring with frequent numbers of *Idiognathodus* sp. A and *Anchignathodus minutus* in samples of the upper South Bend Limestone (Localities 15, 23). In the top of the South Bend Limestone (Localities 14 - 16), *Idiognathodus* sp. A is rare to frequent, with *A. minutus* frequent, and *Stepanovites conflexa* rare in one sample. Although numbers are low, the general trends observed in the samples of South Bend Limestones are: 1) conodont diversity increases slightly upward, 2) *Idiognathodus* sp. A increases in number upward and dominates most of the samples toward the top.

Weston Shale Member

Overlying the Stanton Formation, the Weston Shale Member of the Stranger Formation is considered to be an outside shale that swamped the South Bend cyclothem before an upper limestone could develop (Heckel and Baesemann, 1975), although the base may represent the core shale of the South Bend cyclothem (P.H. Heckel, personal communication, 1976). In one sample collected at the base at Locality 15 (EQ), *Idiognathodus* sp. A is frequent in number, and *Anchignathodus minutus* and *Stepanovites conflexa* are rare.

Summary

The major trends observed in conodont abundance in the Stanton Formation are: 1) increase upward from the Vilas and downward from the top of the Stoner, converging on the Eudora Shale, which contains the greatest abundance and diversity of conodonts; 2) the Eudora and adjoining portions of overlying and underlying members have unique occurrences of three species (*I. typus*, *G. bella*, *Anchignathodus* sp. A); and 3) there is a secondary minor increase in numbers and diversity of conodonts upward from the Rock Lake Shale to the top of the South Bend Limestone.

SUMMARY OF INDIVIDUAL CONODONT DISTRIBUTIONS

Of the 138 processed samples, 21 were completely barren of conodonts, and 4 additional samples only yielded unidentifiable fragments. Only one conodont genus is present in 19 of the samples, and only one species is present in 11 samples. All of the conodont species that are identified in this study (Table 1) are found together in only one sample, which was collected in the channel at Locality 12 (ARC) from the base of the Stoner Limestone.

Distribution of *Adetognathus lautus* and *Adetognathus gigantus*

Two species of *Adetognathus*, *A. lautus* and *A. gigantus*, are the only species of *Adetognathus* identified in the samples processed in this study. These species are considered together as *Adetognathus* spp. in this section for three reasons: 1) both species occur in very low numbers in most of the samples that were processed; 2) specific identification is determined only by the right-sided P element; 3) when they can be differentiated, the distribution patterns of the two species appear to be similar.

Adetognathus spp. are present in low numbers at the

Table 1--Alphabetized listing of all conodont species identified in this study together with their major references, additional synonymy, and necessary remarks.

Table 1

Apparatus - Species

Adetognathus gigantus (Gunnell)(see Lane, 1967, p. 932-933; Baesemann, 1973, p. 697-699)

Adetognathus lautus (Gunnell)(see Lane, 1967, p. 933)

Aethotaxis advena Baesemann (see Baesemann, 1973, p. 697-699)

Anchignathodus minutus (Ellison)(see Ellison, 1941, p. 120; Sweet, 1970, p. 7; Baesemann, 1973, p. 704-706)

Anchignathodus? n. sp. A
Remarks: Lack of a basal cavity tip, and smaller more numerous denticles distinguish the P element of Anchignathodus? n. sp. A from the P element of A. minutus.

Idiognathodus delicatus Gunnell (see Baesemann, 1973, p. 699-703)

Idiognathodus elegantulus (Stauffer & Plummer)(see Baesemann, 1973, p. 703)

Idiognathodus sp. A (= I. cf. elegantulus)(Ellison)(see Ellison, 1941, Pl. 22, fig. 3)
Remarks: Long posterior extention of carina to or nearly to the end of the platform distinguishes Idiognathodus sp. A from I. elegantulus.

Idioprioniodus typus Gunnell (see Ellison, 1941, p. 113-118; Baesemann, 1973, p. 703-704; Merrill & Merrill, 1974, p. 120)

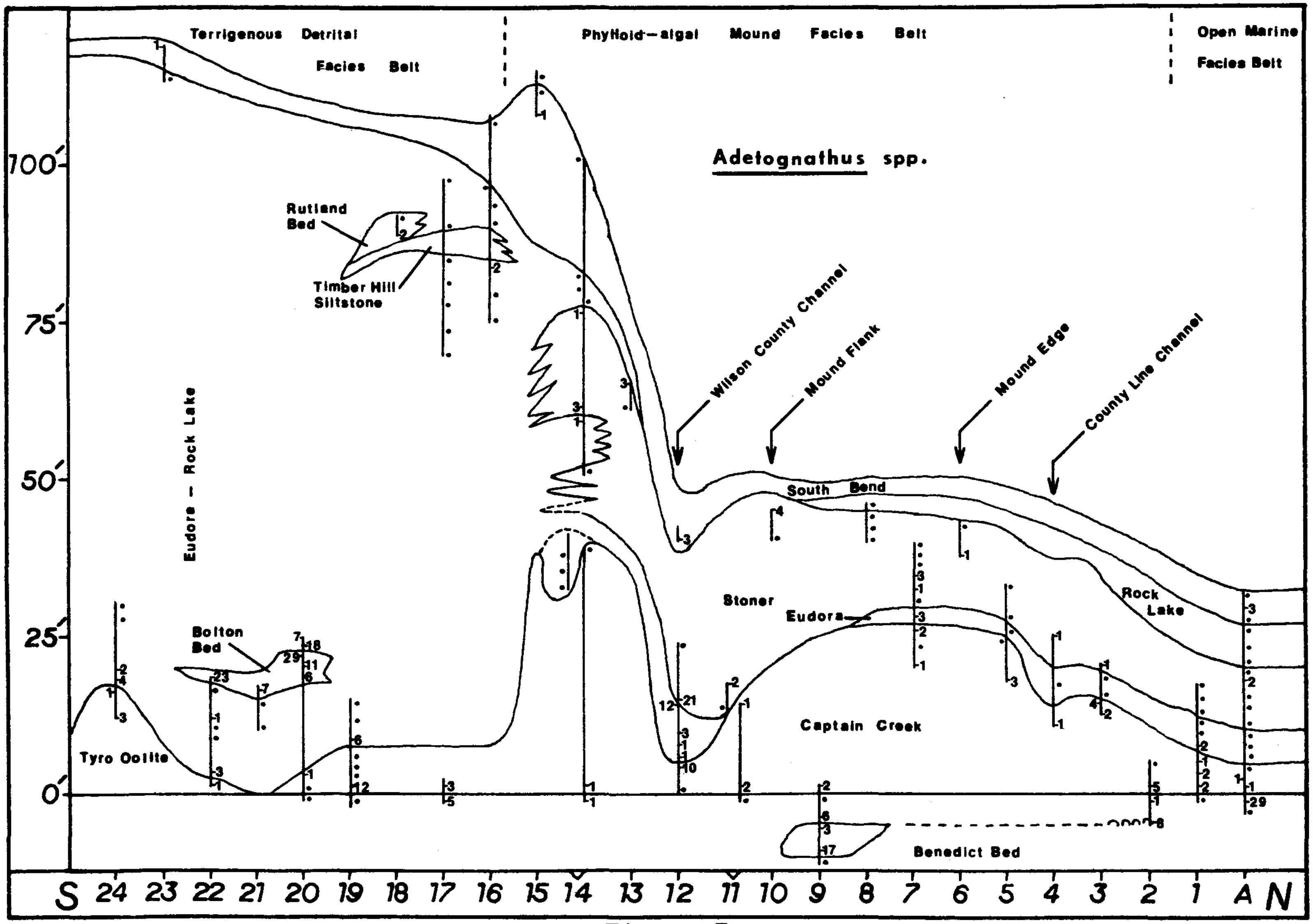
Gondolella bella Stauffer & Plummer (see Clark & Mosher, 1966, p. 383-388; Von Bitter, 1976, p. 12-23)
Gondolella costata Ellison (1941, p. 124)
Gondolella curvata Stauffer & Plummer (1932, p. 25, 42)
Gondolella lobata Ellison (1941, p. 125)
Gondolella magna Stauffer & Plummer (1932, p. 43-44)
Gondolella sublanceolata Gunnell (1933, p. 278)
Remarks: The numerous Missourian species of Gondolella appear gradational in some samples and are synonymized in this study.

Stepanovites conflexa (Ellison)(see Von Bitter, 1972, p. 72-74; Kozur, 1975, p. 1-44, Pl. 1-4; Merrill & Von Bitter, 1976, p. 4, table 1)

Disjunct Unassigned Elements

Hindeodella parva Ellison (see Ellison, 1941, p. 117-118) top of the Vilas Shale and in all subdivisions sampled from the Stanton Formation in southeastern Kansas (Figure 7). They are not present in the sample processed at the base of the Weston Shale (Locality 15, ECQ). In southeastern Kansas, Adetognathus spp. are present in most of the lithologies within the Stanton Formation (Appendix B), which include: stromatolites, oolites, calcilutites, skeletal calcarenites, sandy calcarenites, shale, and in one exceptional sample of non-phosphatic fissile black shale (Appendix B) collected in the flank of Wilson County channel at Locality 12 (ARC). Adetognathus spp. apparently occur most frequently throughout the Bolton bed (Localities 20 - 22), in skeletal oolites like those in the Benedict bed (Localities 2, 9) and in the base of the Captain Creek at Locality 19 (WM), in the fossiliferous Rock Lake Shale at Locality 20 (#27) and associated with the channel at Locality 12 (ARC) in the top of the Captain Creek, upper Eudora, and base of the Stoner. Adetognathus spp. are not present in most samples of fissile black shale (Localities 1, 4, 19, 22), or in the sandy, relatively unfossiliferous samples of Rock Lake Shale (Localities 8, 14, 16, 17). They are generally absent to rare in most samples processed in the top of the Vilas Shale, top of the Eudora Shale, upper South Bend, and throughout most of the Stoner Limestone (Figure 7). Adetognathus spp. are present in 65 (58%) of the 113

Figure 7--Cross section showing distribution of _Adetognathus_ spp. in subdivisions and facies of Stanton Formation along Stanton outcrop belt. Baesemann's section (A) and collected sections 1 - 24 arranged in north-south order. Distances between collecting localities on figure 7 do not reflect true distances between exposures, which are indicated on figures 2, 4, and 5. Datum is base of Captain Creek, with vertical control from field measurements (indicated by vertical lines) from Heckel (1975b, Figures 11a and b). Number indicates total elements per kilogram of sample, with dot representing no elements found. Several of Baesemann's samples combined and averaged to nearest whole number.



Terrigenous Detrital
Facies Belt
Phylloid-algal Mound Facies Belt
Open Marine
Facies Belt
Adetognathus spp.
Rutland Bed
Timber Hill Siltstone
Eudora - Rock Lake
Wilson County Channel
Mound Flank
Mound Edge
County Line Channel
South Bend
Stoner
Eudora
Rock Lake
Captain Creek
Tyro Oolite
Bolton Bed
Benedict Bed
100'
75'
50'
25'
0'
S 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 A N

Figure 7

samples that contained identifiable conodont elements, and, in 8 samples, they represent the only conodont genus present. _Adetognathus_ spp. occur with each other conodont species in 43 to 64% of the samples (explained on Tables 2 and 3); this further illustrates its scattered occurrence. The general trend observed in the distribution pattern of _Adetognathus_ spp. in southeastern Kansas is that they are generally scattered everywhere but concentrated locally, as in the Benedict bed and Bolton bed, and in the base of the Captain Creek, and base of the Stoner at one locality each; they are rarely found in black shales.

Distribution of _Aethotaxis advena_

Aethotaxis advena is rare and in only 5 (4%) of the 113 conodont-bearing samples in the Stanton Formation (Figure 8). Three of the five samples containing _A. advena_ were collected in the sponge-rich calcilutite facies of the Captain Creek Limestone. Three of the four samples processed from this facies contained _A. advena_. It is also present in 2 of the 33 samples processed from the Stoner Limestone Member of the Stanton Formation, but only as one element per sample. One of these two samples is from the middle of the Stoner at Locality 1b (PTC) in the open marine facies belt (Figure 2), and the other is from the base of the Stoner at Locality 12 (ARC), in the Wilson County Channel (Figure 4). _Anchignathodus minutus_

Table 2--List of conodont species showing total abundance and frequency of occurrence with each other by sample.

Table 2

	Total Occurrence by Sample	Isolated Occurrence	Indeterminate Species	Adetognathus spp.	lautus	gigantus	Aethotaxis advena	Stepanovites conflexa	Anchignathodus minuta	Anchignathodus? sp. A	Idiognathodus spp.	elegantulus	delicatus	sp. A	Idioprioniodus typus
Adetognathus spp.	65	8	36	X											
lautus	23	1			X										
gigantus	17	0			10	X									
Aethotaxis advena	5	0	0	3	2	1	X								
Stepanovites conflexa	18	0	0	10	5	4	1	X							
Anchignathodus minutus	66	2	0	36	11	5	5	16							
Anchignathodus? sp. A	14	0	0	6	2	2	1	5	5	X					
Idiognathodus spp.	98	9	15	57	20	13	5	17	61	14	X				
elegantulus	55	1		33	13	10	3	9	42	8		X			
delicatus	48	3		25	11	8	3	12	30	12		33	X		
sp. A	41	4		21	9	6	2	8	21	10		20	27	X	
Idioprioniodus typus	31	0	0	19	6	4	1	11	22	11	31	25	29	19	X
Gondolella bella	33	0	0	21	8	4	1	11	25	11	33	27	32	20	29

Table 3--Maximum percentage of association between individual conodont species calculated by dividing number of co-occurrences by lowest total occurrences of the two species compared. For example: 1) for the least abundant conodont, *Aethotaxis*, 60 in the *Adetognathus* spp. column means that 60% of samples with *Aethotaxis* also had *Adetognathus spp*.; 2) for *I. typus* and *G. bella*, each occurred in 27% and 29% of all samples respectively, but every sample with these two also had *Idiognathodus*.

Table 3

	% of conodont-bearing samples	Adetognathus spp.	Aethotaxis advena	Stepanovites conflexa	Anchignathodus minutus	Anchignathodus sp. A	Idiognathodus spp.	elegantulus	delicatus	sp. A	Idioprioniodus typus
Adetognathus spp.	58	X									
Aethotaxis advena	4	60	X								
Stepanovites conflexa	16	56	20	X							
Anchignathodus minutus	58	55	100	89	X						
Anchignathodus? sp. A	12	43	20	36	57	X					
Idiognathodus spp.	87	88	100	94	92	100	X				
elegantulus	49	60	60	50	76	57		X			
delicatus	42	52	60	67	63	86		69	X		
sp. A	36	51	40	44	51	71		49	66	X	
Idioprioniodus typus	27	61	20	61	71	79	100	81	94	61	X
Gondolella bella	29	64	20	61	76	79	100	82	97	61	94

Figure 8--Cross section showing distribution of *Aethotaxis advena* in subdivisions and facies of Stanton Formation along Stanton outcrop belt. For more explanation see figure 7 caption.

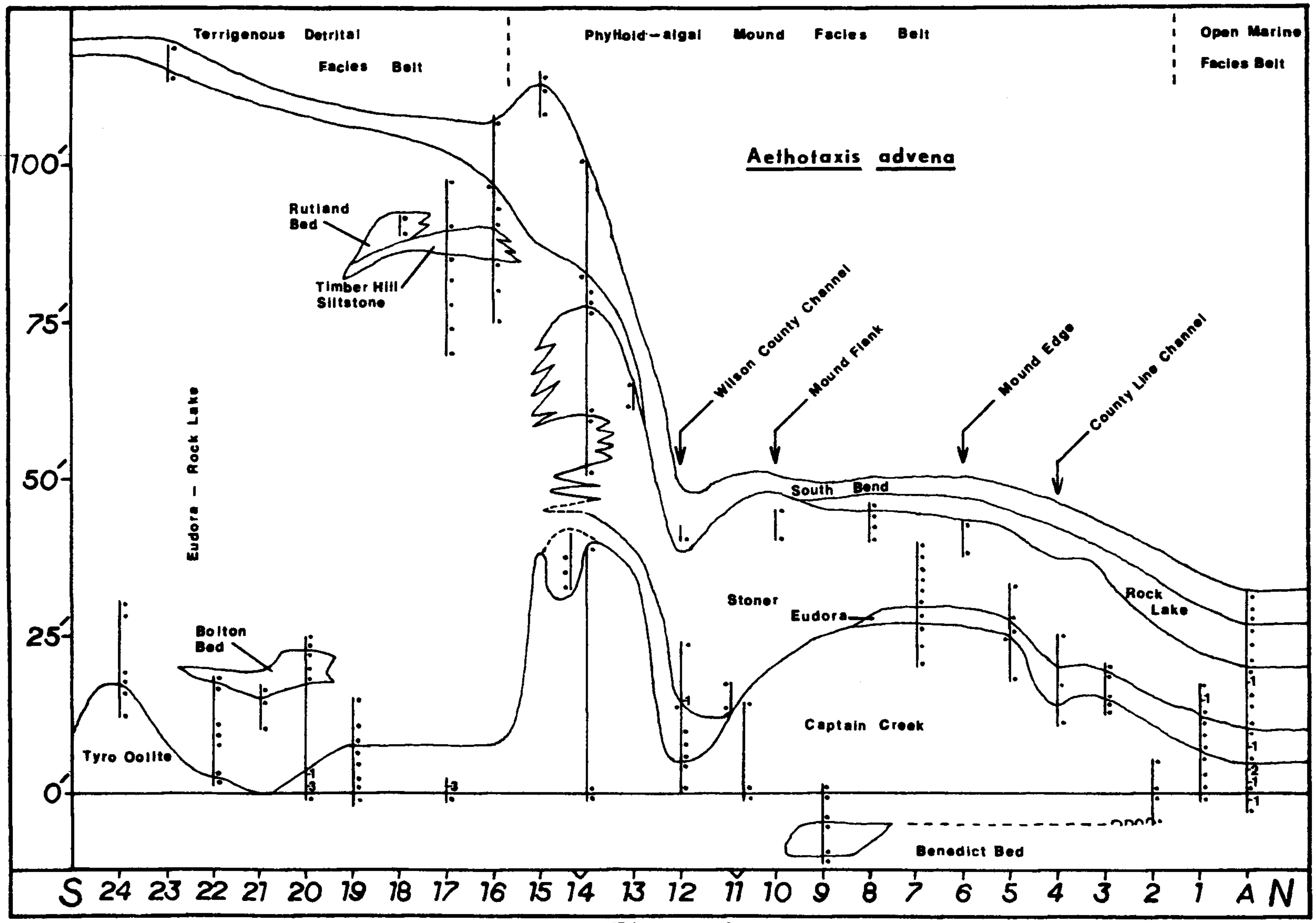

Terrigenous Detrital
Facies Belt
Phylloid-algal Mound Facies Belt
Open Marine
Facies Belt
Aethotaxis advena
100'
75'
50'
25'
0'
Rutland
Bed
Timber Hill
Siltstone
Wilson County Channel
Mound Flank
Mound Edge
County Line Channel
Eudora - Rock Lake
South Bend
Stoner
Eudora
Rock
Lake
Bolton
Bed
Tyro Oolite
Captain Creek
Benedict Bed
S 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 A N

Figure 8

and Idiognathodus spp. are present in all of the five samples containing A. advena; Adetognathus spp., I. elegantulus and I. delicatus are present in three of the five samples (Tables 2 and 3). A. advena is rare but shows a tendency to occur only in limestones away from the algal buildups especially in the sponge calcilutite facies of the Captain Creek Limestone south of the algal buildup.

Distribution of Stepanovites conflexa

Stepanovites conflexa is present in low numbers in most of the members of the Stanton Formation and at the base of the Weston Shale (Figure 9). It is present in only 18 (16%) of the 113 samples that contained identifiable conodont elements. It is not present in the samples processed from the Vilas Shale, Tyro oolite, or Rock Lake Shale. It is present in low numbers in one sample each of the Benedict bed (Locality 2), Captain Creek Member (Locality 7), Bolton bed (Locality 20), Rutland bed (Locality 18), and South Bend Member (Locality 15). S. conflexa occurs most frequently and in greatest numbers in the Eudora Shale (Localities 1, 5, 12, 19) and at the base of the Stoner Limestone (Localities 1, 3, 5, 7, 12). It occurs in stromatolites, calcilutites, calcarenites, shales, and in one exceptional sample (see Appendix B) of non-phosphatic fissile black shale collected from the flank of the Wilson County channel at Locality 12 (ARC).

Figure 9--Cross section showing distribution of *Stepanovites conflexa* in subdivisions and facies of Stanton Formation along Stanton outcrop belt. For more explanation see figure 7 caption.

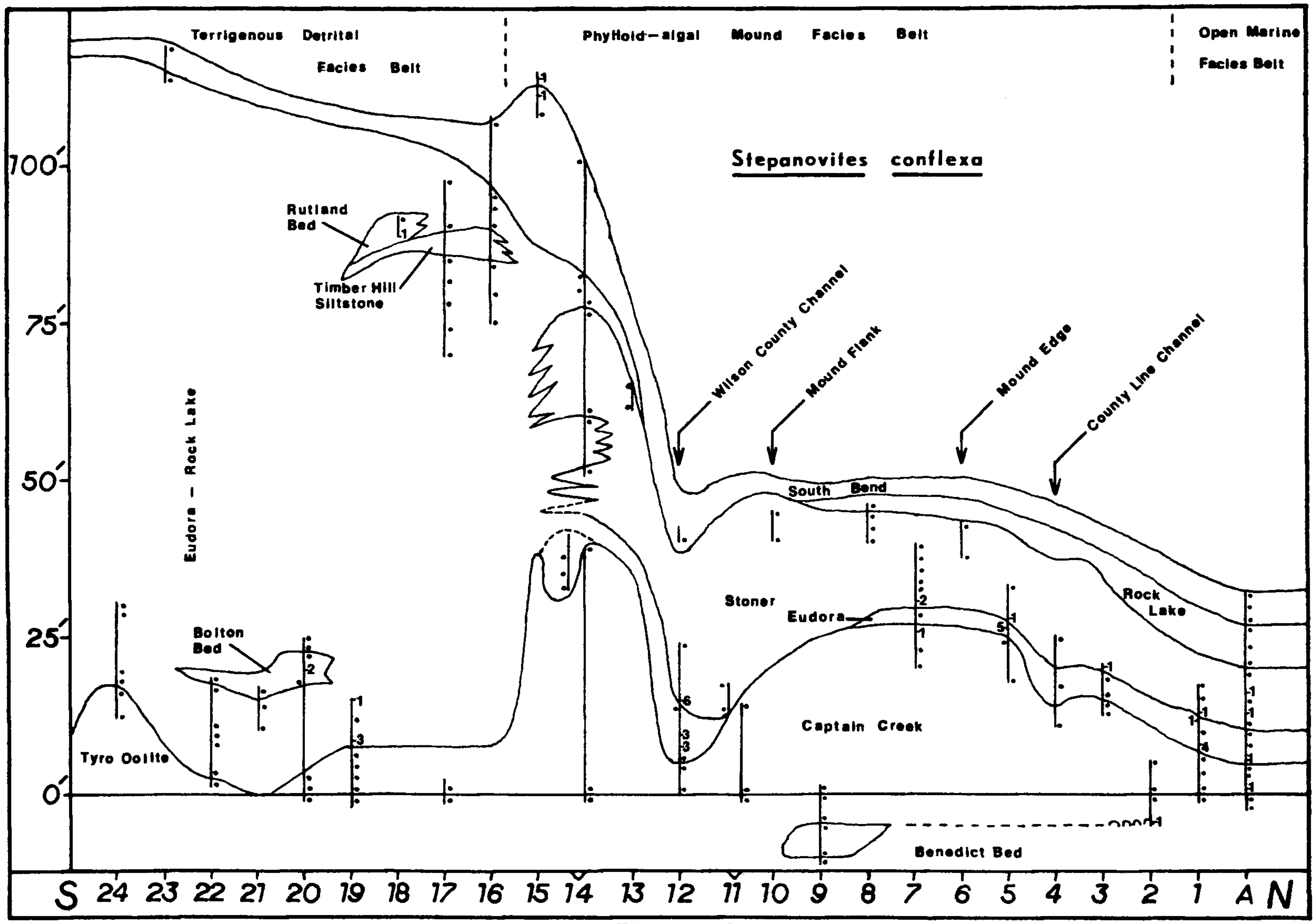

Terrigenous Detrital Facies Belt
Phylloid—algal Mound Facies Belt
Open Marine Facies Belt
Stepanovites conflexa
100′
75′
50′
25′
0′
Rutland Bed
Timber Hill Siltstone
Eudora — Rock Lake
Wilson County Channel
Mound Flank
Mound Edge
County Line Channel
South Bend
Stoner
Eudora
Rock Lake
Bolton Bed
Tyro Oolite
Captain Creek
Benedict Bed
S 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 A N

Figure 9

It is not present in sandy, silty, or oolitic samples or in most black shales (Localities 1, 4, 19, 22). Idiognathodus spp. occurs commonly with S. conflexa (94%), Aethotaxis advena rarely (20%), and other genera occur with it in one-third to three-fifths of samples (36 - 61%)(Tables 2 and 3). In summary, S. conflexa is rare but occurs most frequently in the non-black Eudora Shale and at the base of the Stoner Limestone.

Distribution of Anchignathodus minutus

In southeastern Kansas, Anchignathodus minutus is found in samples processed from the top of the Vilas Shale, in most of the subdivisions of the Stanton Formation, and at the base of the Weston Shale (Figure 10). It is not present in the samples processed from the Bolton bed, Rutland bed, or the Rock Lake Shale. A. minutus is present in most Stanton lithologies including: stromatolites, oolites, calcilutites, skeletal calcarenites, fossiliferous shale, and in the black shale at Locality 12 (ARC). It is not present in the processed samples of sandy, silty, or poorly fossiliferous shale, sandy calcarenites, and most black shales. A. minutus occurs most frequently in samples processed from the phylloid-algal mound facies belt (Localities 2 - 14)(Figure 10); it occurs in greater numbers toward the top in the Captain Creek and South Bend Limestones and at the base

Figure 10--Cross section showing distribution of *Anchignathodus minutus* in subdivisions and facies of Stanton Formation along Stanton outcrop belt. For more explanation see figure 7 caption.

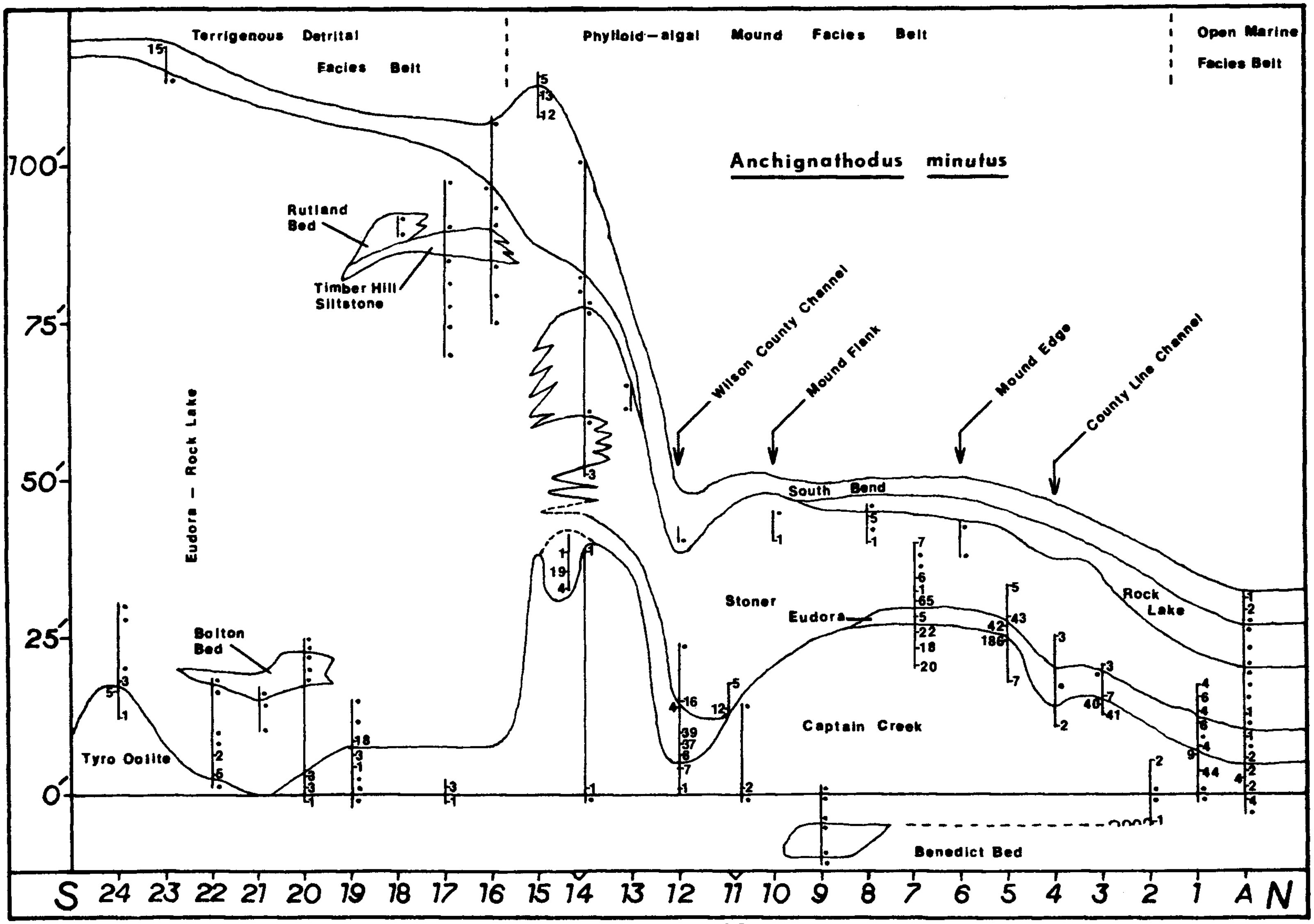

Terrigenous Detrital
Facies Belt
Phylloid-algal Mound Facies Belt
Open Marine
Facies Belt
Anchignathodus minutus
Rutland
Bed
Timber Hill
Siltstone
Wilson County Channel
Mound Flank
Mound Edge
County Line Channel
South Bend
Eudora — Rock Lake
Stoner
Eudora
Rock
Lake
Bolton
Bed
Captain Creek
Tyro Oolite
Benedict Bed
100′
75′
50′
25′
0′
S 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 A N

Figure 10

in the Stoner Limestone. *A. minutus* is the second most frequently occurring conodont, appearing in 66 (58%) of the 113 samples that contained identifiable conodont elements, and it is the only conodont species recovered in 2 samples. It occurs in all of the samples containing *A. advena*; between 92 and 89% of the samples with *Idiognathodus* spp. and *Stepanovites conflexa*; and least, between 55 and 51%, with *Adetognathus* spp. and *Idiognathodus* sp. A (Tables 2 and 3). The general trends observed in the distribution patterns of *A. minutus* in the Stanton in southeastern Kansas are: 1) it occurs most frequently in the phylloid-algal mound facies belt, 2) it tends to increase in numbers upward toward the top of the Captain Creek Limestone and downward toward the base of the Stoner Limestone, 3) it is common in the Eudora Shale except in the black shale facies, and 4) it shows a possible secondary increase in numbers upward toward the top of the South Bend Limestone.

Distribution of *Anchignathodus*? sp. A

Anchignathodus? sp. A is rare in the samples that were processed in the Stanton Formation in southeastern Kansas, occurring in 14 (12%) of the 113 samples containing identifiable conodont elements. It appears most frequently in the Eudora Shale, where it occurs in greatest numbers in the fissile phosphatic black facies and in the immediately

Figure 11--Cross section showing distribution of *Anchignathodus*? sp. A in subdivisions and facies of Stanton Formation along Stanton outcrop belt. For more explanation see figure 7 caption.

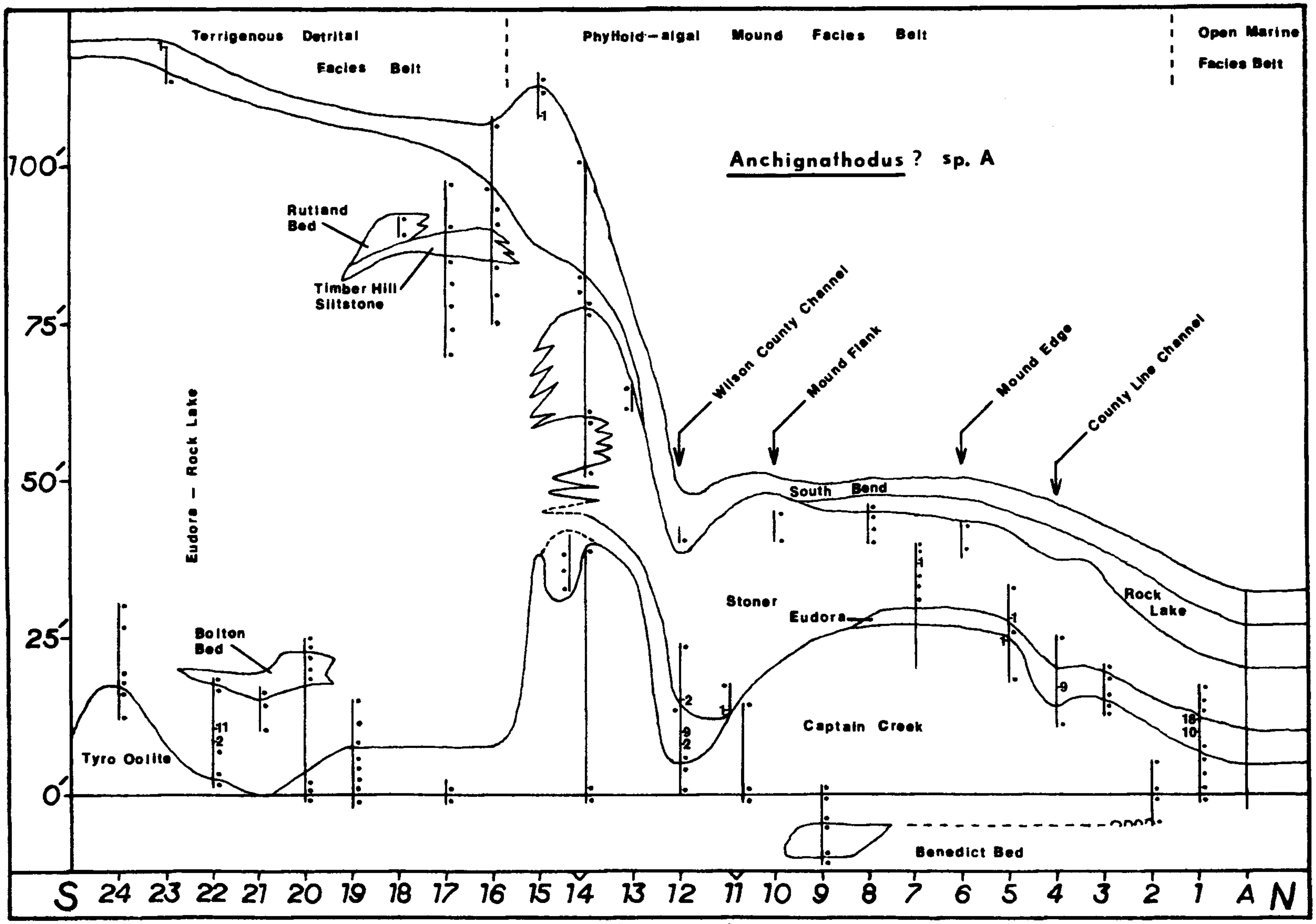

Terrigenous Detrital
Facies Belt
Phylloid—algal Mound Facies Belt
Open Marine
Facies Belt
Anchignathodus ? sp. A
100'
75'
50'
25'
0'
Rutland Bed
Timber Hill Siltstone
Wilson County Channel
Mound Flank
Mound Edge
County Line Channel
South Bend
Eudora — Rock Lake
Stoner
Eudora
Rock Lake
Bolton Bed
Tyro Oolite
Captain Creek
Benedict Bed
S 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 A N

Figure 11

overlying gray shale (Figure 11). It also is present in one sample collected at the top of the Captain Creek Limestone (Locality 5), in four samples collected at or near the base of the Stoner Limestone (Localities 5, 7, 11, 12), and in two samples collected in the upper South Bend Limestone (Localities 15, 23). It is not present in the samples processed from any of the other units. Anchignathodus? sp. A is present in the following lithologies: shale, black shale, calcarenite, and calcilutite. It is not present in the samples of stromatolite, oolite, sandy or silty shales, or sandy limestones. Species of Idiognathodus are present in all 14 samples containing Anchignathodus? sp. A, and I. delicatus occurs most commonly. Idioprioniodus typus and Gondolella bella occur in 79% of the samples yielding Anchignathodus? sp. A (Tables 2 and 3). The general trends observed in the distribution patterns of Anchignathodus? sp. A are: 1) it occurs in greatest numbers in or near the Eudora Shale, where it is found in or directly above the phosphatic black shale facies, and 2) it occurs in low numbers in the upper South Bend Limestone.

Distribution of Idiognathodus

Idiognathodus is present in 98 (87%) of the 113 samples containing identifiable conodont elements. It is

Figure 12--Cross section showing distribution of *Idiognathodus* spp. in subdivisions and facies of Stanton Formation along Stanton outcrop belt. For more explanation see figure 7 caption.

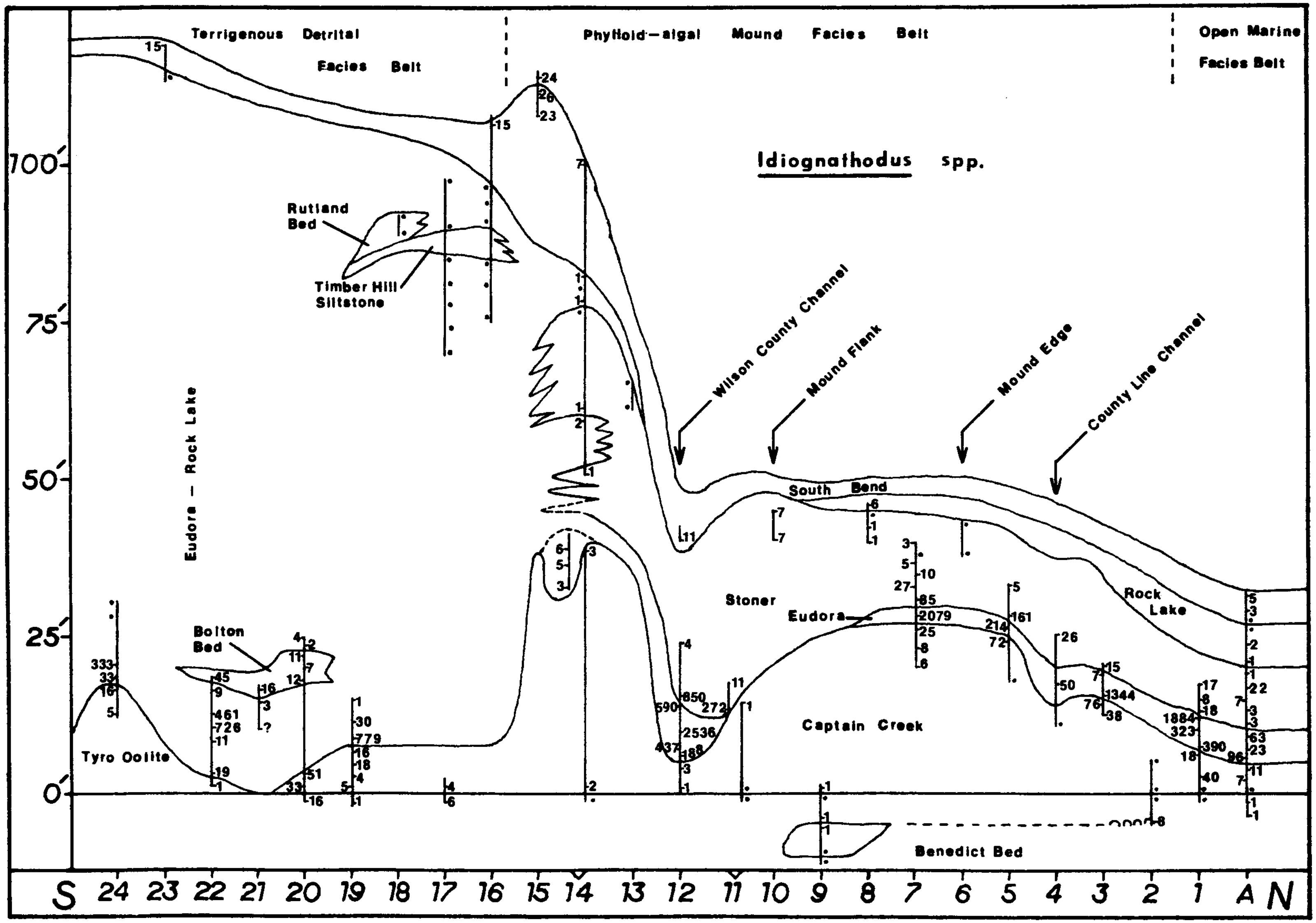

Terrigenous Detrital Facies Belt
Phylloid–algal Mound Facies Belt
Open Marine Facies Belt
Idiognathodus spp.
Rutland Bed
Timber Hill Siltstone
Wilson County Channel
Mound Flank
Mound Edge
County Line Channel
South Bend
Eudora — Rock Lake
Stoner
Eudora
Rock Lake
Captain Creek
Bolton Bed
Tyro Oolite
Benedict Bed
100´
75´
50´
25´
0´
S 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 A N

Figure 12

the most frequently occurring and generally the most abundant conodont genus recovered (Figure 12). It is present in samples collected from all stratigraphic subdivisions studied for this report except the Rutland bed (Locality 18). Species of Idiognathodus are present in all processed lithologies (stromatolites, oolites, calcilutites, skeletal calcarenites, clay shales, sandy shales, and black shales). Idiognathodus is extremely abundant in the Eudora Shale and decreases upward and downward in the adjacent limestone members; it increases again upward in the South Bend Limestone.

Distribution of Idiognathodus elegantulus

Idiognathodus elegantulus is present in 55 (49%) of the 113 samples containing identifiable conodont elements. It is present in samples collected from all of the stratigraphic subdivisions studied in this report except the Benedict bed and Rutland bed, and the base of the Weston Shale. It is present in most of the processed lithologies (oolites, calcilutites, skeletal and sandy calcarenites, and in clay and black shales). It is not identified in the samples of sandy and silty shale or in the stromatolite. I. elegantulus generally occurs in low numbers in samples collected in the Vilas Shale, Tyro oolite, sponge calcilutite and shale facies of the Captain Creek Member, the Bolton bed, and Stoner Limestone. It is present in low numbers and in only one sample collected in the base of the Rock Lake Shale at Locality 20 (#27). It is recovered in largest numbers in most of the samples collected in the Eudora Shale Member (Localities 1, 3, 5, 7, 12, 19). *I. elegantulus* occurs most commonly with *Gondolella bella* (82%), *Idioprioniodus typus* (81%), and *Anchignathodus minutus* (76%) and least commonly with *Idiognathodus* sp. A (49%) and *Stepanovites conflexa* (50%) (Tables 2 and 3). The general trend observed in the distribution patterns of *I. elegantulus* is an increase in numbers upward from the Vilas Shale and downward from the South Bend Limestone Member into the Eudora Shale Member, where it occurs in maximum numbers.

Distribution of *Idiognathodus delicatus*

Idiognathodus delicatus is present in all of the members processed in the Stanton Formation except for the Benedict and Rutland beds. It is not present in the samples processed from either the Vilas Shale or base of the Weston Shale. It is identified in most of the Stanton lithologies except for the stromatolite and silty shales. *I. delicatus* is present in low numbers and is present in only one sample processed in the Captain Creek sponge calcilutite facies (Locality 20), Rock Lake Shale (Locality 14), and South Bend Limestone (Locality 12). It does not occur in the samples processed in the Captain

Creek Limestone in the open marine facies belt (Locality 1), and it occurs only in the top of the Captain Creek Limestone in the phylloid-algal mound facies belt (Figure 2, Localities 3, 5, 7, 12). It is present in many of the samples processed in the Stoner Limestone Member (Localities 1, 3, 4, 5, 7, 10, 11, 12) and Bolton bed (Localities 20 - 22), and increases in number downward toward the Eudora Shale Member where it occurs in maximum numbers.

I. delicatus is recovered from 48 (42%) of the 113 samples containing identifiable conodont elements, and in three samples, it is the only conodont species present. It occurs most commonly, between 86 and 97%, with Gondolella bella, Idioprioniodus typus, and Anchignathodus? sp. A, and only slightly less commonly with the other conodonts in this study (Tables 2 and 3). I. delicatus is generally the most abundant conodont species that is recovered from the samples processed from the Eudora Shale Member.

Distribution of Idiognathodus sp. A

Idiognathodus sp. A is present in the one sample processed from the base of the Weston Shale, and in all subdivisions of the Stanton Formation above the Captain Creek Limestone Member except for the Rutland bed. It occurs in only one Captain Creek sample, the top at

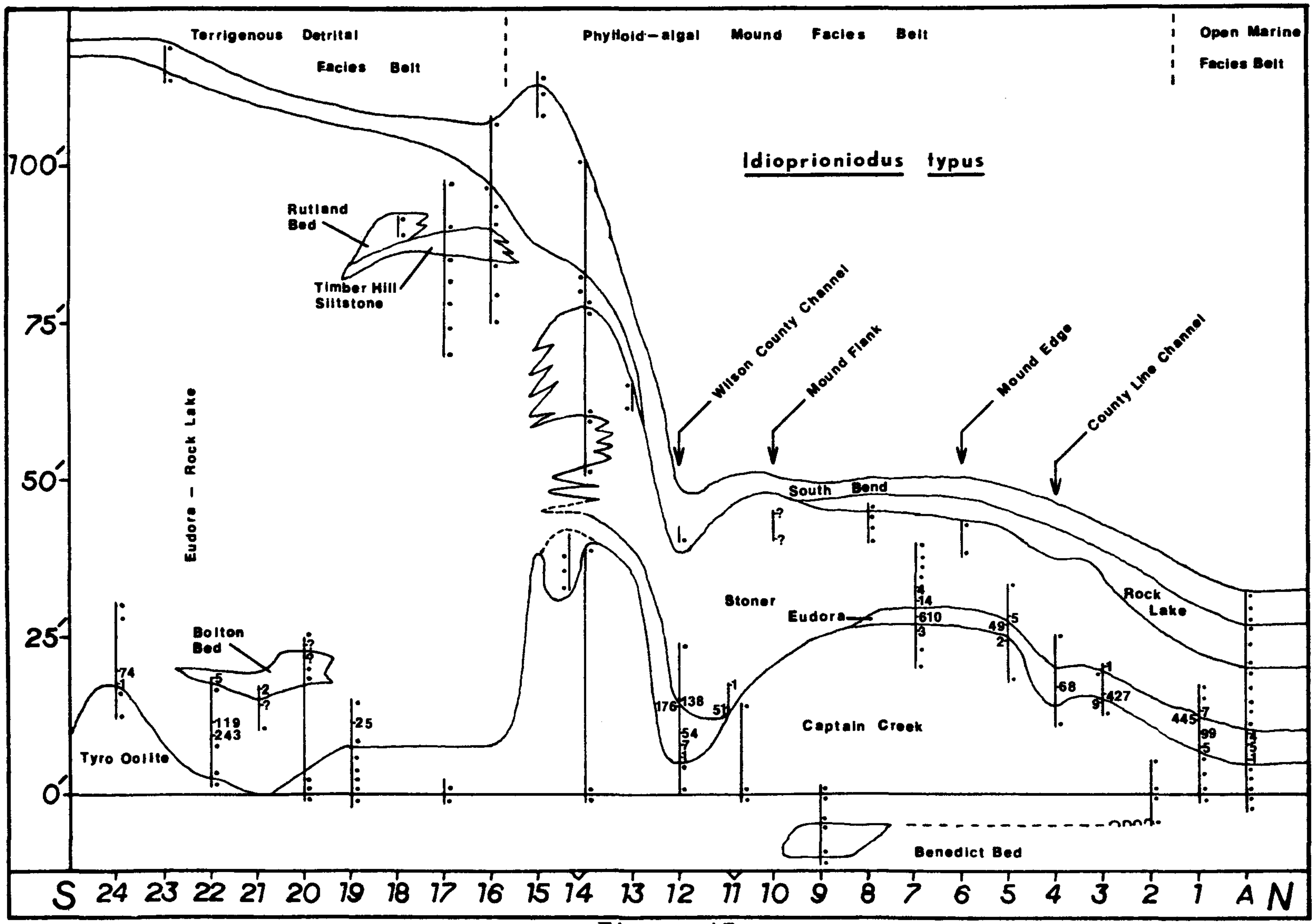
Locality 3 (2QSP). *Idiognathodus* sp. A occurs in most Stanton lithologies except for stromatolite, oolite, and silty shale. It is present in most Stoner samples, generally increasing in numbers downward to its maximum in the base and in the underlying Eudora Shale (Localities 1, 3, 4, 5, 7, 11, 12, 14). A secondary increase in numbers is apparent upward from the Rock Lake Shale through South Bend Limestone into the base of the Weston Shale (Localities 8, 12, 14, 15, 16, 20, 22). *Idiognathodus* sp. A occurs in 41 (36%) of the 113 samples containing identifiable conodont elements, and it is the only species identified in 4 of the samples. It occurs with other species of *Idiognathodus* most frequently and in a large percentage of samples with *Anchignathodus*? sp. A (71%), *I. delicatus* (66%), *Idioprioniodus typus* (61%)(Tables 2 and 3). The general distributional trends observed with *Idiognathodus* sp. A are: 1) increase in numbers downward in the Stoner Member occurring in maximum numbers in the base and in the Eudora Shale, 2) a secondary increase in numbers upward in the Rock Lake Shale and South Bend Limestone, occurring in largest numbers in the Weston Shale, and 3) only rare occurrence below the Eudora Shale Member.

Distribution of *Idioprioniodus typus*

Idioprioniodus typus is present in 31 (27%) of the 113 samples containing identifiable conodont elements. Species of *Idiognathodus* are present in all of these 31 samples. *I. typus* occurs in most of its samples with *I. delicatus* (94%) and *Gondolella bella* (94%)(Tables 2 and 3).

I. typus is present only in samples processed from the top of the Captain Creek Limestone, throughout the Eudora Shale, in the lower part of the Stoner Limestone, and at the base of the Bolton bed (Figure 13). *I. typus* is present in many of the Stanton lithologies including: calcilutite, skeletal calcarenite, skeletal oolite, clay shale, and black shale. It is not present in samples of sandy calcarenite, sandy shale, silty shale, or stromatolite. *I. typus* attains highest numbers in samples of Eudora from the phosphatic gray to black shale facies (Localities 1, 3, 4, 5, 7, 12, 19, 22, 24). The general distributional trends observed for *I. typus* are:
1) occurrence in all three facies belts, but only in the Eudora Shale and in adjoining parts of overlying and underlying units, and 2) increase in numbers toward the Eudora Shale where it occurs in maximum numbers.

Figure 13--Cross section showing distribution of *Idioprioniodus typus* in subdivisions and facies of Stanton Formation along Stanton outcrop belt. For more explanation see figure 7 caption.


Terrigenous Detrital Facies Belt
Phylloid-algal Mound Facies Belt
Open Marine Facies Belt
Idioprioniodus typus
Rutland Bed
Timber Hill Siltstone
Wilson County Channel
Mound Flank
Mound Edge
County Line Channel
Eudora - Rock Lake
South Bend
Stoner
Eudora
Rock Lake
Bolton Bed
Tyro Oolite
Captain Creek
Benedict Bed
100'
75'
50'
25'
0'
S 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 A N
Figure 13

Distribution of *Gondolella bella*

Gondolella bella is present in 33 (29%) of the 113 samples containing identifiable conodont elements. Species of *Idiognathodus* are present in all of these 33 samples. *G. bella* occurs in most of its samples with *I. delicatus* (97%) and *Idioprioniodus typus* (94%)(Tables 2 and 3).

G. bella is present only in samples from the top of the Captain Creek Limestone, throughout the Eudora Shale and Bolton bed, and in the lower part of the Stoner Limestone (Figure 14). It is present in the sample collected in the probable middle Stoner Limestone at Locality 10 (BB) on the mound flank below the rim facies of the Stoner Limestone buildup. *G. bella* is present in many Stanton lithologies including: calcilutite, skeletal calcarenite, skeletal oolite, clay shale, and black shale. It is not present in samples of sandy calcarenite, sandy shale, silty shale, or stromatolite. *G. bella* occurs in highest numbers in samples of Eudora Shale that were collected in the phosphatic black and associated gray shale. The general distributional trends observed for *G. bella* are: 1) occurrence in all three facies belts, but mainly in the Eudora Shale and in adjoining parts of overlying and underlying units; 2) increase in numbers toward the Eudora Shale where it typically occurs in maximum numbers.

Figure 14--Cross section showing distribution of *Gondolella bella* in subdivisions and facies of Stanton Formation along Stanton outcrop belt. For more explanation see figure 7 caption.

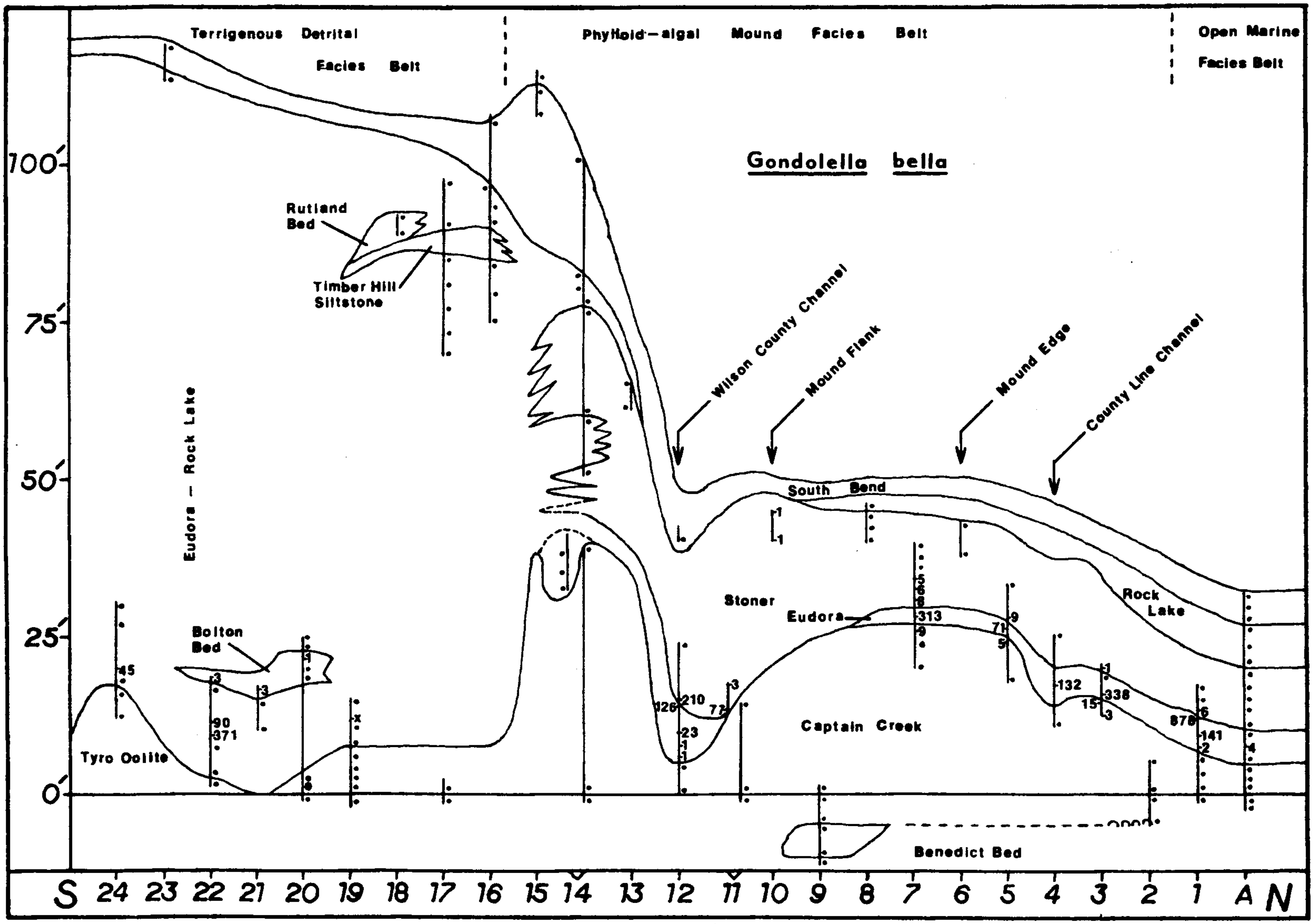

Terrigenous Detrital Facies Belt
Phylloid-algal Mound Facies Belt
Open Marine Facies Belt
Gondolella bella
100'
75'
50'
25'
0'
Rutland Bed
Timber Hill Siltstone
Eudora — Rock Lake
Wilson County Channel
Mound Flank
Mound Edge
County Line Channel
South Bend
Stoner
Eudora
Rock Lake
Bolton Bed
Tyro Oolite
Captain Creek
Benedict Bed
S 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 A N

Figure 14

CONCLUSIONS

The same basic pattern of vertical conodont distribution seen in the Stanton Formation in northeastern Kansas (Heckel and Baesemann, 1975) holds true for southeastern Kansas in every sequence studied. Abundance and diversity increase upward from the Vilas Shale through the Captain Creek Limestone into the Eudora Shale, then decreases upward through the Stoner Limestone to the Rock Lake Shale, and finally show a secondary slight increase upward in the South Bend Limestone. Thus greatest abundance and diversity are present in the core shale and adjacent portions of the limestone units which represent the phase of maximum transgression and deepest water in the cyclothem (Heckel, 1975b, 1977).

Anchignathodus? sp. A, *Idioprioniodus typus*, and *Gondolella bella* are confined to sediments deposited in deepest water during maximum transgression in the cyclothem sequence. *Adetognathus* spp., *Idiognathodus minutus*, *Aethotaxis advena*, and *Stepanovites conflexa* are distributed more generally throughout the cyclothem, with *Idiognathodus* spp. and *Anchignathodus minutus* generally increasing in numbers toward the core shale.

Lithology is apparently not the controlling factor over the deeper water Idioprioniodus typus, Anchignathodus? sp. A, and Gondolella bella, as they are present in different types of offshore limestones including calcilutites, calcarenites, and skeletal oolite in addition to the black and gray shales where they are most common. Furthermore, they were not found in similar lithologies deposited during the shallow water phase in the cyclothem.

Disaggregation of the black anoxic facies of the offshore shale yielded mainly Idiognathodus spp., Anchignathodus? sp. A, Idioprioniodus typus, and Gondolella bella. These species probably were pelagic because the black shale facies is considered to be mainly anoxic (Heckel, 1977).

Another line of evidence supporting a depth-related control over conodont distribution is occurrence of one of the inferred deeper-water forms, Gondolella bella, stratigraphically higher in the Stoner Member at Locality 10, which is topographically lower on the flank of the algal-mound buildup.

The actual factors controlling Stanton conodont distribution in southeastern Kansas are most likely depth related, such as oxygen concentration, temperature, salinity, and light penetration, rather than strictly depth, i.e. pressure alone (Heckel and Baesemann, 1975, p. 504-505). These controlling factors probably were related to different water masses present at different depths, and the exact positions of these masses may have depended also on less well understood geographic factors as well as on water depth.

In general, two depth-related zones are suggested by the conodont distribution patterns observed in the Stanton cyclothem in southeastern Kansas. Species in one zone include: *Adetognathus* spp., *Idiognathodus* spp., *Anchignathodus minutus*, *Aethotaxis advena*, and *Stepanovites conflexa*. They apparently lived in the upper water layer, because they are found through all depths represented in the cyclothem; the upper water layer tends to be warmer and better oxygenated. Species in the other zone include: *Anchignathodus*? sp. A, *Idioprioniodus typus*, and *Gondolella bella* which are found only in deeper water deposits of the cyclothem. They were apparently confined to the cooler, less oxygenated, deeper water mass drawn into the sea during maximum transgression (Heckel, 1977).

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APPENDIX A

TABULATED CONODONT DISTRIBUTIONS

APPENDIX A

TABULATED CONODONT DISTRIBUTIONS

Table 4--Tabulations by locality of recovered conodont species for each sample. A standard sample size of one kilogram was processed for conodonts, except for the two 2-kilogram samples collected from Locality 19. Lithologic symbols are standard, with black platy shale facies solidly lined and stromatolites irregular and finely lined. Letters stand for: T=top, U=upper, M=middle, L=lower, B=base of each member or bed; and numbers stand for approximate distances above base or below top. Refer to appendix B for precise positioning of samples in each unit.

Table 4

Locality 1a, b

VILAS		CAPTAIN CREEK (9 ft.)					EUDORA (22 in.)			STONER					
	T	B		M	1a/1b	T	B	M	T	B		M	U		
		1												P	Adetognathus lautus
														O1	
														N	
				1		1								A1	
														A2	
				1										A3	
														P	A. gigantus
		1					2							P	A. sp.
														X	Aethotaxis advena
												1		A3	
														?	
							2							B1	Stepanovites conflexa
									1					B2?	
							2			1				B3	
														B?	
				9		6	2			3				P	Anchignathodus minutus
				10					4			2	1	O1	
				6		1			1			2	1	N	
				10								1		A1	
				7		1			1					A2	
				2		1						1		A3	
							2	1		1			1	P	A. sp.
								9	18					P	A.? sp. A
								2	3					A1	Hindeodella parva
							111	141	1260	13		1	3	P	Idiognathodus delicatus
				5			8	31	166	1		2	2	O1	
				2				4	31	1		1	3	N	
				6		1		3	12			1		A1a	
								2	9				2	A1b	
				1									3	A2	
				2		1			10					A3	
				6		4	185	23	144					P	I. elegantulus
								3	59			1	3	P	I. sp. A
				18		12	86	116	193	3		2		P	I. sp.
								14	49	1				N	Idioprioniodus typus
							3	53	216	2				B1a	
								5	44	2				B1b	
							1	11	50	1				B2	
								8	38					B3a	
							1	8	48	1				B3b	
							2	98	487	2				P	Gondolella bella
								20	210	2				O1	
								6	94					N	
								3	38	2				B1	
								14	45					B2	
									4					B3	

Table 4 (cont'd.)

VILAS	CAPTAIN CREEK					Locality 2
	B	T	B	U		
	1		2		P	Adetognathus lautus
	1				O1	
					N	
					A1	
					A2	
					A3	
			1		P	A. gigantus
	6	1	2		P	A. sp.
					X	Aethotaxis advena
					A3	
					?	
					B1	Stepanovites conflexa
					B2?	
	1				B3	
					B?	
				2	P	Anchignathodus minutus
					O1	
					N	
					A1	
	1				A2	
					A3	
					P	A. sp.
					P	A.? sp. A
					A1	Hindeodella parva
					P	Idiognathodus delicatus
					O1	
					N	
					A1a	
					A1b	
					A2	
					A3	
					P	I. elegantulus
					P	I. sp. A
	8				P	I. sp.
					N	Idioprioniodus typus
					B1a	
					B1b	
					B2	
					B3a	
					B3b	
					P	Gondolella bella
					O1	
					N	
					B1	
					B2	
					B3	

Table 4 (cont'd.)

CAPTAIN CREEK				EUDORA		STONER	Locality 3	
2	TL	T	TU	B	U	L		
	1		1				P	Adetognathus lautus
						1	O1	
2							N	
		3					A1	
	1	2					A2	
		1					A3	
							P	A. gigantus
		1					P	A. sp.
							X	Aethotaxis advena
							A3	
							?	
						1	B1	Stepanovites conflexa
							B2?	
							B3	
							B?	
7	6	8	13	2		1	P	Anchignathodus minutus
5	4	2	5	2			O1	
5	6	5	5	1		1	N	
12	12	15	11				A1	
6	4	11	3			1	A2	
5		3	2				A3	
1	1	3		2			P	A. sp.
							P	A.? sp. A
1		1	1				A1	Hindeodella parva
5	31	4	19	720	4	6	P	Idiognathodus delicatus
3	16	4	9	53		1	O1	
2	1	3	5	8		1	N	
4	3	3	5	2		1	A1a	
			1				A1b	
	1		2				A2	
1		1		1			A3	
12	9	7	8	66			P	I. elegantulus
			3	36	3	3	P	I. sp. A
11	37	26	29	458		2	P	I. sp.
	2	1		73			N	Idioprioniodus typus
	6	1	3	183			B1a	
	2			41			B1b	
	2	1	3	50		1	B2	
	1		1	31			B3a	
	3		1	49			B3b	
3	13	4	12	282			P	Gondolella bella
	3		3	30			O1	
	1			10			N	
	4		1	9			B1	
	3			7		1	B2	
							B3	

Table 4 (cont'd.)

CAPTAIN CREEK		COVERED INTERVAL (5 ft.)	EUDORA (1 ft)	STONER				Locality 4
	U		U		M			
							P	Adetognathus lautus
							O1	
							N	
	1				1		A1	
							A2	
							A3	
							P	A. gigantus
							P	A. sp.
							X	Aethotaxis advena
							A3	
							?	
							B1	Stepanovites conflexa
							B2?	
							B3	
							B?	
					2		P	Anchignathodus minutus
							O1	
					1		N	
	1						A1	
							A2	
	1						A3	
							P	A. sp.
			9				P	A.? sp. A
			2				A1	Hindeodella parva
			21		12		P	Idiognathodus delicatus
			16		1		O1	
			2				N	
							A1a	
			3				A1b	
			1				A2	
			1				A3	
							P	I. elegantulus
			2		11		P	I. sp. A
			4		2		P	I. sp.
			5				N	Idioprioniodus typus
			38				B1a	
			6				B1b	
			6				B2	
			4				B3a	
			9				B3b	
			55				P	Gondolella bella
			40				O1	
			6				N	
			10				B1	
			21				B2	
							B3	

Table 4 (cont'd)

CAPTAIN CREEK		EUDORA	STONER		Locality 5	
M	T	B	B	U		
					P	Adetognathus lautus
1					O1	
					N	
1					A1	
					A2	
					A3	
					P	A. gigantus
1					P	A. sp.
					X	Aethotaxis advena
					A3	
					?	
		4	1		B1	Stepanovites conflexa
		1			B2?	
					B3	
					B?	
2	58	20	22	1	P	Anchignathodus minutus
1	22	7	1		O1	
1	16	1	3		N	
1	46	4	6	2	A1	
1	33		5		A2	
1			1	2	A3	
		10	5		P	A. sp.
	1		1		P	A.? sp. A
			1		A1	Hindeodella parva
	11	110	35		P	Idiognathodus delicatus
	11	17	20	1	O1	
	6	4	5	1	N	
		1	2		A1a	
			3	2	A1b	
	2		1		A2	
	2	1	1		A3	
	35	40	5		P	I. elegantulus
		7	51	1	P	I. sp. A
	5	34	38		P	I. sp.
		8	1		N	Idioprioniodus typus
	1	25	2		B1a	
		2	2		B1b	
		5			B2	
	1	5			B3a	
		4			B3b	
	2	43	5		P	Gondolella bella
	3	13	1		O1	
		5			N	
		5	2		B1	
		5	1		B2	
					B3	

Table 4 (cont'd.)

STONER L	STONER T	ROCK LAKE	Element	Locality 6
			P	Adetognathus lautus
1	1?		O1	
			N	
			A1	
			A2	
			A3	
			P	A. gigantus
			P	A. sp.
			X	Aethotaxis advena
			A3	
			?	
			B1	Stepanovites conflexa
			B2?	
			B3	
			B?	
			P	Anchignathodus minutus
			O1	
			N	
			A1	
			A2	
			A3	
			P	A. sp.
			P	A.? sp. A
			A1	Hindeodella parva
			P	Idiognathodus delicatus
			O1	
			N	
			A1a	
			A1b	
			A2	
			A3	
			P	I. elegantulus
			P	I. sp. A
			P	I. sp.
			N	Idioprioniodus typus
			B1a	
			B1b	
			B2	
			B3a	
			B3b	
			P	Gondolella bella
			O1	
			N	
			B1	
			B2	
			B3	

Table 4 (cont'd.)

CAPTAIN CREEK			EUDORA	STONER						Locality 7	
L	M	T	B	B	1	2	3	5	U		
						1				P	Adetognathus lautus
						1				O1	
										N	
		2	1							A1	
										A2	
1										A3	
										P	A. gigantus
			3		1	1				P	A. sp.
										X	Aethotaxis advena
										A3	
										?	
		1		2						B1	Stepanovites conflexa
										B2?	
										B3	
										B?	
4	4	6	3	35	1	4			3	P	Anchignathodus minutus
1	4	4		4		1			1	O1	
6	3	1		5		1				N	
5	4	5	1	9						A1	
3	2	1		4					2	A2	
1	1	2	1						1	A3	
		3		8						P	A. sp.
							1			P	A.? sp. A
										A1	Hindeodella parva
		5	918	31	10	3	2			P	Idiognathodus delicatus
	1	3	64	8	1	2	1		1	O1	
			6	2		1				N	
1			3	1			1	?1		A1a	
			2	1						A1b	
	2									A2	
			1	2						A3	
3		2	170	6	2					P	I. elegantulus
			52		8	3	1		2	P	I. sp. A
2	5	15	863	34	6	1				P	I. sp.
			81	2						N	Idioprioniodus typus
		2	280	7	2					B1a	
		1	61	1						B1b	
			79	1						B2	
			45	2	1					B3a	
			64	1	1					B3b	
		6	266	5	5					P	Gondolella bella
		3	29		1	2				O1	
			9	2		3				N	
			6	1						B1	
			3							B2	
										B3	

Table 4 (cont'd.)

STONER			ROCK LAKE	Locality 8	
4	1	T	L		
				P	*Adetognathus lautus*
				O1	
				N	
				A1	
				A2	
				A3	
				P	*A. gigantus*
				P	*A. sp.*
				X	*Aethotaxis advena*
				A3	
				?	
				B1	*Stepanovites conflexa*
				B2?	
				B3	
				B?	
		1		P	*Anchignathodus minutus*
				O1	
				N	
		1		A1	
		1		A2	
				A3	
1		2		P	*A. sp.*
				P	*A.? sp. A*
				A1	*Hindeodella parva*
				P	*Idiognathodus delicatus*
1			1	O1	
				N	
				A1a	
				A1b	
				A2	
				A3	
				P	*I. elegantulus*
			3	P	*I. sp. A*
	1		2	P	*I. sp.*
				N	*Idioprioniodus typus*
				B1a	
				B1b	
				B2	
				B3a	
				B3b	
				P	*Gondolella bella*
				O1	
				N	
				B1	
				B2	
				B3	

Table 4 (cont'd.)

VILAS		BENEDICT BED (4½')		CAPTAIN CREEK			Locality 9
T	B		T	B	T	B		
	1			2			P	Adetognathus lautus
							O1	
							N	
							A1	
							A2	
							A3	
	6			1			P	A. gigantus
	10		3	3		2	P	A. sp.
							X	Aethotaxis advena
							A3	
							?	
							B1	Stepanovites conflexa
							B2?	
							B3	
							B?	
							P	Anchignathodus minutus
							O1	
							N	
							A1	
							A2	
							A3	
							P	A. sp.
							P	A.? sp. A
							A1	Hindeodella parva
							P	Idiognathodus delicatus
							O1	
							N	
							A1a	
							A1b	
							A2	
							A3	
							P	I. elegantulus
							P	I. sp. A
			1	1		1	P	I. sp.
							N	Idioprioniodus typus
							B1a	
							B1b	
							B2	
							B3a	
							B3b	
							P	Gondolella bella
							O1	
							N	
							B1	
							B2	
							B3	

Table 4 (cont'd.)

STONER	M		U			Locality 10
					P	Adetognathus lautus
			1		O1	
					N	
			1		A1	
					A2	
			1		A3	
					P	A. gigantus
			1		P	A. sp.
					X	Aethotaxis advena
					A3	
					?	
					B1	Stepanovites conflexa
					B2?	
					B3	
					B?	
					P	Anchignathodus minutus
					O1	
					N	
					A1	
					A2	
					A3	
	1				P	A. sp.
					P	A.? sp. A
					A1	Hindeodella parva
	2		1		P	Idiognathodus delicatus
	2		2		O1	
					N	
					A1a	
					A1b	
					A2	
					A3	
	1		1		P	I. elegantulus
					P	I. sp. A
	2		3		P	I. sp.
					N	Idioprioniodus typus
	?		?		B1a	
					B1b	
					B2	
					B3a	
					B3b	
			1		P	Gondolella bella
					O1	
	1				N	
					B1	
					B2	
					B3	

Table 4 (cont'd.)

VILAS	CAPTAIN CREEK (12 ft.)		STONER					Locality 11
	T	B	F	U	B	M		
			2				P	Adetognathus lautus
		1		1			O1	
							N	
							A1	
							A2	
							A3	
							P	A. gigantus
		1				2	P	A. sp.
							X	Aethotaxis advena
							A3	
							?	
							B1	Stepanovites conflexa
							B2?	
							B3	
							B?	
					4	1	P	Anchignathodus minutus
					2		O1	
						2	N	
					3		A1	
							A2	
					1		A3	
		2			2	2	P	A. sp.
					1		P	A.? sp. A
							A1	Hindeodella parva
					73		P	Idiognathodus delicatus
					23	1	O1	
				1	1	1	N	
					2	2	A1a	
					2		A1b	
							A2	
							A3	
					54		P	I. elegantulus
					11	3	P	I. sp. A
			2		106	4	P	I. sp.
					3		N	Idioprioniodus typus
					23		B1a	
					6		B1b	
					7		B2	
					4		B3a	
					8	1	B3b	
					56		P	Gondolella bella
					8	1	O1	
					6	1	N	
					3	1	B1	
					4		B2	
							B3	

Table 4 (cont'd.)

VILAS	CAPTAIN CREEK		EUDORA (14 in.)					STONER			SOUTH BEND			Locality 12a,b,c
	B	12a/	T	B	1	2	T	B		U	b/c	L		
			3		1			2					P	Adetognathus lautus
			1				1					1	O1	
													N	
			2										A1	
													A2	
													A3	
			1			2		6				2	P	A. gigantus
			3	1		3	11	13					P	A. sp.
													X	Aethotaxis advena
								1					A3	
													?	
					2	2		3					B1	Stepanovites conflexa
					1			1					B2?	
						1		2					B3	
													B?	
			4	5	14	16		5					P	Anchignathodus minutus
					3	4		4					O1	
					3	4		3					N	
	1		2	2	11	4							A1	
					2	1		1					A2	
				1	1	1							A3	
			1		3	9	4	3					P	A. sp.
					2	9		2					P	A.? sp. A
					1	2		5					A1	Hindeodella parva
			1	46	109	816	179	180				6	P	Idiognathodus delicatus
				4	27	135	34	80		1			O1	
	1				6	29	3	16					N	
					2	14	1	10				1	A1a	
					5	9	1	6					A1b	
						2							A2	
					4	5		4					A3	
			2	91	112	1002	154	325				1	P	I. elegantulus
						1	51	68		3		2	P	I. sp. A
				47	172	523	167	161				1	P	I. sp.
				1	2	7	39	20					N	Idioprioniodus typus
					1	26	57	59					B1a	
					1	2	25	20					B1b	
					1	7	19	13					B2	
					1	6	10	2					B3a	
					1	6	26	24					B3b	
					1	16	88	124					P	Gondolella bella
				1		3	23	41					O1	
						3	9	20					N	
							2	17					B1	
						1	4	7					B2	
													B3	

Table 4 (cont'd.)

STONER			ROCK LAKE		
					Locality 13
	U	T			
				P	Adetognathus lautus
				O1	
		1		N	
				A1	
				A2	
		1		A3	
				P	A. gigantus
		1		P	A. sp.
				X	Aethotaxis advena
				A3	
				?	
				B1	Stepanovites conflexa
				B2?	
				B3	
				B?	
				P	Anchignathodus minutus
				O1	
				N	
				A1	
				A2	
				A3	
				P	A. sp.
				P	A.? sp. A
				A1	Hindeodella parva
				P	Idiognathodus delicatus
				O1	
				N	
				A1a	
				A1b	
				A2	
				A3	
				P	I. elegantulus
				P	I. sp. A
				P	I. sp.
				N	Idioprioniodus typus
				B1a	
				B1b	
				B2	
				B3a	
				B3b	
				P	Gondolella bella
				O1	
				N	
				B1	
				B2	
				B3	

Table 4 (cont'd.)

VILAS	CAPTAIN CREEK		covered			STONER				ROCK LAKE			SOUTH BEND	Locality 14	
T	B	T	L	M	U	L	T	B	T	B	M	T	T		
														P	Adetognathus lautus
									1					O1	
														N	
														A1	
														A2	
								2						A3	
														P	A. gigantus
1	1						1	1						P	A. sp.
														X	Aethotaxis advena
														A3	
														?	
														B1	Stepanovites conflexa
														B2?	
														B3	
														B?	
	1		3	7	1	1								P	Anchignathodus minutus
				4										O1	
		1	1	3										N	
				2		2								A1	
				1										A2	
				1										A3	
				1										P	A. sp.
														P	A.? sp. A
														A1	Hindeodella parva
										1				P	Idiognathodus delicatus
	1			2										O1	
														N	
														A1a	
														A1b	
														A2	
					1									A3	
		2	2	3	3	1								P	I. elegantulus
							2					1	7	P	I. sp. A
	1	1	1		2			1						P	I. sp.
														N	Idioprioniodus typus
														B1a	
														B1b	
														B2	
														B3a	
														B3b	
														P	Gondolella bella
														O1	
														N	
														B1	
														B2	
														B3	

Table 4 (cont'd.)

SOUTH BEND | WESTON

Locality 15

U	T	B	Element	Species
			P	*Adetognathus lautus*
			O1	
			N	
			A1	
			A2	
			A3	
			P	*A. gigantus*
1			P	*A. sp.*
			X	*Aethotaxis advena*
			A3	
			?	
			B1	*Stepanovites conflexa*
	1	1	B2?	
			B3	
			B?	
9	10	2	P	*Anchignathodus minutus*
			O1	
1	1		N	
	1		A1	
	1		A2	
1			A3	
1		3	P	*A. sp.*
1			P	*A.? sp. A*
			A1	*Hindeodella parva*
			P	*Idiognathodus delicatus*
4	2	1	O1	
1	4		N	
3	1		A1a	
			A1b	
	2		A2	
2			A3	
			P	*I. elegantulus*
13	17	23	P	*I. sp. A*
			P	*I. sp.*
			N	*Idioprioniodus typus*
			B1a	
			B1b	
			B2	
			B3a	
			B3b	
			P	*Gondolella bella*
			O1	
			N	
			B1	
			B2	
			B3	

Table 4 (cont'd.)

EUDORA L	EUDORA M	EUDORA T	TIMBER HILL	ROCK LAKE B	ROCK LAKE M	ROCK LAKE T	ONION CREEK	SOUTH BEND T		Locality 16
									P	*Adetognathus lautus*
									O1	
									N	
									A1	
									A2	
									A3	
		2							P	*A. gigantus*
									P	*A. sp.*
									X	*Aethotaxis advena*
									A3	
									?	
									B1	*Stepanovites conflexa*
									B2?	
									B3	
									B?	
									P	*Anchignathodus minutus*
									O1	
									N	
									A1	
									A2	
									A3	
									P	*A. sp.*
									P	*A.? sp. A*
									A1	*Hindeodella parva*
									P	*Idiognathodus delicatus*
									O1	
									N	
									A1a	
									A1b	
									A2	
								1	A3	
									P	*I. elegantulus*
								14	P	*I. sp. A*
									P	*I. sp.*
									N	*Idioprioniodus typus*
									B1a	
									B1b	
									B2	
									B3a	
									B3b	
									P	*Gondolella bella*
									O1	
									N	
									B1	
									B2	
									B3	

Table 4 (cont'd.)

VILAS	CAPTAIN CREEK		EUDORA				TIMBER HILL	ROCK LAKE	ONION CREEK		Locality 17a,b
T	B	a/b	L	11	8	3	TB	T			
1	1									P	*Adetognathus lautus*
2										O1	
										N	
	1			?1						A1	
										A2	
										A3	
										P	*A. gigantus*
2	1									P	*A.* sp.
	1									X	*Aethotaxis advena*
										A3	
	2									?	
										B1	*Stepanovites conflexa*
										B2?	
										B3	
										B?	
										P	*Anchignathodus minutus*
	1									O1	
										N	
	2									A1	
										A2	
										A3	
1										P	*A.* sp.
										P	*A.?* sp. A
										A1	*Hindeodella parva*
										P	*Idiognathodus delicatus*
										O1	
										N	
										A1a	
										A1b	
										A2	
										A3	
1										P	*I. elegantulus*
										P	*I.* sp. A
5	4									P	*I.* sp.
										N	*Idioprioniodus typus*
										B1a	
										B1b	
										B2	
										B3a	
										B3b	
										P	*Gondolella bella*
										O1	
										N	
										B1	
										B2	
										B3	

Table 4 (cont'd.)

RUTLAND BED (8 ft.)

Locality 18

L		U	Element	Taxon
			P	Adetognathus
1			O1	lautus
			N	
			A1	
			A2	
			A3	
2			P	A. gigantus
1			P	A. sp.
			X	Aethotaxis
			A3	advena
			?	
1			B1	Stepanovites
			B2?	conflexa
			B3	
			B?	
			P	Anchignathodus
			O1	minutus
			N	
			A1	
			A2	
			A3	
			P	A. sp.
			P	A.? sp. A
			A1	Hindeodella parva
			P	Idiognathodus
			O1	delicatus
			N	
			A1a	
			A1b	
			A2	
			A3	
			P	I. elegantulus
			P	I. sp. A
			P	I. sp.
			N	Idioprioniodus
			B1a	typus
			B1b	
			B2	
			B3a	
			B3b	
			P	Gondolella
			O1	bella
			N	
			B1	
			B2	
			B3	

Table 4 (cont'd.)

Vilas / Captain Creek / Eudora / Timber Hill: Locality 19		VILAS	CAPTAIN CREEK				EUDORA				TIMBER HILL
		T	B	1	5	6	B	2	4	20	
Adetognathus lautus	P						1				
	O1										
	N										
	A1										
	A2										
	A3										
A. gigantus	P		6								
A. sp.	P		6				5				
Aethotaxis advena	X										
	A3										
	?										
Stepanovites conflexa	B1						2			1	
	B2?										
	B3						1				
	B?										
Anchignathodus minutus	P				1	1	7				
	O1										
	N						4				
	A1					1	2				
	A2						3				
	A3										
A. sp.	P					1	2				
A.? sp. A	P										
Hindeodella parva	A1										
Idiognathodus delicatus	P							18			
	O1						15	2			
	N						2	1			
	A1a						1				
	A1b										
	A2										
	A3										
I. elegantulus	P	1		2	11	11	556	1			
I. sp. A	P							1			
I. sp.	P		5	2	7	5	205	7		1	
Idioprioniodus typus	N							2			
	B1a							13			
	B1b							1			
	B2							5			
	B3a							1			
	B3b							3			
Gondolella bella	P								X		
	O1										
	N										
	B1										
	B2										
	B3										

Table 4 (cont'd.)

VILAS		CAPTAIN CREEK			cov.	BOLTON BED					ROCK LAKE			ONION CREEK	Locality 20	
	T	B		U		B		M		T	B		U			
						1		1		2	6		1		P	Adetognathus lautus
						1				1					O1	
															N	
										1					A1	
															A2	
															A3	
						2		4		11			1		P	A. gigantus
				1		2		6		14	12		5		P	A. sp.
		1													X	Aethotaxis advena
															A3	
		2		1											?	
								1							B1	Stepanovites conflexa
								1							B2?	
															B3	
															B?	
				2											P	Anchignathodus minutus
	1			1											O1	
		1													N	
		2													A1	
															A2	
															A3	
															P	A. sp.
															P	A.? sp. A
										1					A1	Hindeodella parva
		3				3		5		1					P	Idiognathodus delicatus
				1											O1	
															N	
															A1a	
															A1b	
				2											A2	
															A3	
	13	21		22		1				1			2		P	I. elegantulus
						8				6	2		2		P	I. sp. A
	3	9		26				2		3					P	I. sp.
															N	Idioprioniodus typus
										?1	?1				B1a	
															B1b	
															B2	
															B3a	
															B3b	
															P	Gondolella bella
															O1	
															N	
										1					B1	
															B2	
															B3	

Table 4 (cont'd.)

EUDORA				BOLTON BED			Locality 21
	M		T	B			
				4		P	Adetognathus lautus
						O1	
						N	
						A1	
						A2	
						A3	
						P	A. gigantus
				3		P	A. sp.
						X	Aethotaxis advena
						A3	
						?	
						B1	Stepanovites conflexa
						B2?	
						B3	
						B?	
						P	Anchignathodus minutus
						O1	
						N	
						A1	
						A2	
						A3	
						P	A. sp.
						P	A.? sp. A
						A1	Hindeodella parva
			3	7		P	Idiognathodus delicatus
						O1	
						N	
	?4					A1a	
						A1b	
						A2	
						A3	
				3		P	I. elegantulus
				2		P	I. sp. A
				4		P	I. sp.
						N	Idioprioniodus typus
			?1	1		B1a	
				1		B1b	
						B2	
						B3a	
						B3b	
				3		P	Gondolella bella
						O1	
						N	
						B1	
						B2	
						B3	

Table 4 (cont'd.)

TYRO OOLITE		EUDORA (14 ft.)							BOLTON BED			Locality 22
	T	B		5	6	7		T	B			
		2							3		P	Adetognathus lautus
		1									O1	
											N	
											A1	
											A2	
											A3	
									6		P	A. gigantus
	1					1			14		P	A. sp.
											X	Aethotaxis advena
											A3	
											?	
											B1	Stepanovites conflexa
											B2?	
											B3	
											B?	
											P	Anchignathodus minutus
		1									O1	
											N	
		1		2							A1	
		2									A2	
											A3	
		1				2					P	A. sp.
					2	9					P	A.? sp. A
					12	2					A1	Hindeodella parva
				3	414	200		8	24		P	Idiognathodus delicatus
					142	85					O1	
				1	67	16					N	
					24	10					A1a	
					44						A1b	
					11						A2	
					24	5					A3	
		1		5		16			9		P	I. elegantulus
									6		P	I. sp. A
	1	18		2		129		1	6		P	I. sp.
					31	22					N	Idioprioniodus typus
					103	47					B1a	
					26	10			4		B1b	
					32	12			1		B2	
					16	7					B3a	
					35	21					B3b	
					147	35			2		P	Gondolella bella
					83	12					O1	
					60	15					N	
					36	6					B1	
					41	19			1		B2	
					4	3					B3	

Table 4 (cont'd.)

ROCK LAKE T	SOUTH BEND F	SOUTH BEND U	Element	Locality 23
			P	*Adetognathus lautus*
			O1	
			N	
			A1	
			A2	
			A3	
			P	*A. gigantus*
		1	P	*A.* sp.
			X	*Aethotaxis advena*
			A3	
			?	
			B1	*Stepanovites conflexa*
			B2?	
			B3	
			B?	
	4	12	P	*Anchignathodus minutus*
			O1	
	6		N	
	2	2	A1	
	2	1	A2	
			A3	
	4		P	*A.* sp.
	2	1	P	*A.?* sp. A
			A1	*Hindeodella parva*
			P	*Idiognathodus delicatus*
	3		O1	
			N	
	3		A1a	
			A1b	
			A2	
			A3	
			P	*I. elegantulus*
		15	P	*I.* sp. A
	12		P	*I.* sp.
			N	*Idioprioniodus typus*
			B1a	
			B1b	
			B2	
			B3a	
			B3b	
			P	*Gondolella bella*
			O1	
			N	
			B1	
			B2	
			B3	

Table 4 (cont'd.)

TYRO OOLITE		EUDORA	EUDORA - ROCK LAKE			Locality 24	
M	T	B	T	5	8		
						P	Adetognathus lautus
	1	1				O1	
						N	
			1			A1	
						A2	
						A3	
2		1				P	A. gigantus
1		2	1			P	A. sp.
						X	Aethotaxis advena
						A3	
						?	
						B1	Stepanovites conflexa
						B2?	
						B3	
						B?	
	1					P	Anchignathodus minutus
	1					O1	
1		1				N	
	2					A1	
	1	1				A2	
						A3	
		1				P	A. sp.
						P	A.? sp. A
						A1	Hindeodella parva
			96			P	Idiognathodus delicatus
	1		31			O1	
			6			N	
			3			A1a	
			1			A1b	
						A2	
			2			A3	
3	15	21	25			P	I. elegantulus
			9			P	I. sp. A
2		12	160			P	I. sp.
			13			N	Idioprioniodus typus
		?1	37			B1a	
			7			B1b	
			3			B2	
			3			B3a	
			11			B3b	
			38			P	Gondolella bella
			3			O1	
			1			N	
			1			B1	
			2			B2	
						B3	

APPENDIX B

LOCALITY REGISTER WITH SAMPLE DESCRIPTIONS

Exact collecting localities illustrated in figures 2, 5, and 6 with lithologic descriptions of samples processed for conodonts and tabulated in appendix A. Skeletal grain types are listed in decreasing order with most abundant grain types first and least abundant last. Grain types listed before parentheses are considered abundant enough to be major constituents in the sample. Those grain types listed within parentheses are less abundant to rare and in some limestones were observed only in the acid residues.

APPENDIX B

LOCALITY REGISTER WITH SAMPLE DESCRIPTIONS

Locality 1a (McQ), McAdam's Quarry

NE ¼, sec. 1, T20S, R19E; north side of quarry.

Vilas Sh.

T; gray shale, fossils rare, (echinoderms)

Captain Creek Ls.

B; skeletal calcilutite to fine calcarenite with brachiopods, algae, (bryozoans, fusulinids, octracodes, gastropods, fish elements)

M (± 4½ ft.); skeletal calcilutite with algae, brachiopods, bryozoans, (echinoderms, gastropods, fish elements, sponges, orbiculoid brachiopods, foraminifera)

Locality 1b (PTC), Pottawatomie Creek

NW ¼, sec. 4, T20S, R19E; road cut along east side of gravel road.

Captain Creek Ls.

T; skeletal calcilutite with algae, bryozoans, (foraminifera, brachiopods, fish elements)

Eudora Sh.

B; 2 in. thick gray shale with (echinoderms, fish elements, ostracodes, foraminifera)

M; 18 in. thick black platy shale with phosphate, orbiculoid brachiopods, (fish elements, foraminifera)

T; 2 in. thick fossiliferous gray shale with echinoderms, brachiopods, (bryozoans, foraminifera, phosphate, fish elements, coelenterates)

Stoner Ls.

B; skeletal calcilutite (packstone) with echinoderms, (bryozoans, brachiopods, fish elements)

M (+ 1½ ft.); skeletal calcilutite with (brachiopods, echinoderms, algae, bryozoans, sponges, fish elements)

U (+ 4½ ft.); skeletal calcilutite with brachiopods, (fusulinids, echinoderms, bryozoans)

Locality 2 (US54RC), U.S. Highway 54 roadcut

SE ¼, sec. 25, T24S, R17E; roadcut on north side of U.S. Highway 54.

Benedict Bed

0 - 1 ft. thick algal stromatolite, calcilutite, fossils rare, (echinoderms, bryozoans, brachiopods, fish elements)

Captain Creek Sh.

T; 4 - 5 ft. thick fossiliferous tan shale with brachiopods, echinoderms, bryozoans, ostracodes, foraminifera, (gastropods)

Captain Creek Ls.

B; skeletal calcilutite (packstone) with algae, brachiopods, (echinoderms, bryozoans, foraminifera)

U (+ 5 ft.); skeletal calcilutite with algae, (brachiopods, foraminifera, fish elements)

Locality 3 (2QSP), Second quarry south of Piqua

NW $\frac{1}{4}$. SW $\frac{1}{4}$, sec. 3, T25S, R17E; small water filled quarry on east side of gravel road.

Captain Creek Ls.

2 (- 2 in.); skeletal calcilutite with algae, brachiopods, bryozoans, (echinoderms, coelenterates, foraminifera, fish elements, burrows)

T; skeletal calcilutite with brachiopods, algae, (bryozoans, echinoderms, foraminifera, fish elements, spirorbids)

Eudora Sh.

B; fossiliferous tan shale with echinoderms, bryozoans, phosphate, brachiopods, foraminifera, (fish elements, coelenterates)

U (+ 1 ft.); fossiliferous tan shale with echinoderms, bryozoans, brachiopods, (ostracodes, foraminifera, fish elements)

Stoner Ls.

L; skeletal calcarenite with some mud (packstone), brachiopods, bryozoans, echinoderms, (algae, ostracodes, foraminifera, fusulinids, fish elements)

Locality 4 (CLC), County Line Channel

N ¼, sec. 3, T27S, R17E to S ¼, sec. 34, T28S, R17E; outcrop in hog lot and road ditch.

Captain Creek Ls.

U; skeletal calcilutite with algae-sheltered, spar-filled voids containing pellets, (brachiopods, echinoderms, bryozoans, foraminifera)

Eudora Sh.

U (+ 6 ft. from Captain Creek - U); black platy shale, fossils rare, very small phosphate nodules, (orbiculoid brachiopods)

Stoner Ls.

M (+ 5 ft.); skeletal calcilutite (packstone) with algae, brachiopods, (bryozoans, echinoderms, foraminifera, fish elements, gastropods)

Locality 5 (EQ), Erickson's Quarry (non Nelson's Quarry)

N ½, sec. 5, T27S, R17E; shale channel on north side of quarry.

Captain Creek Ls.

M (- 7 ft.); skeletal calcilutite with algae, sheltered, spar-filled voids containing skeletal debris, (brachiopods, echinoderms, bryozoans, bivalves, gastropods)

T; mottled skeletal calcilutite with algae, brachiopods, bryozoans, (echinoderms, foraminifera, ostracodes)

Eudora Sh.

B; 8 in. thick fossiliferous tan shale in channel with echinoderms, phosphate, brachiopods, fish elements, (ostracodes, foraminifera, glauconite, quartz, holothurian elements)

Stoner Ls.

L; skeletal calcarenite with muddy matrix, echinoderms, brachiopods, (bryozoans, fish elements, phosphate)

U (+ 6 ft.); mottled skeletal calcilutite with algae, some sheltering voids, (brachiopods, bryozoans, pellets, fish elements, quartz, sponges, gastropods)

Locality 6 (RCNB), Roadcut north of Buffalo

SW ¼, sec. 5, T27S, R16E; roadcut on east side of U.S. Highway 75.

Stoner Ls.

L (- 5½ ft.); spar-cemented skeletal calcarenite with abraded fragments of brachiopods, echinoderms, (gastropods, bivalves, bryozoans, fusulinids, foraminifera, fish elements, orbiculoid brachiopods, quartz)

T; spar-cemented skeletal calcarenite with brachiopods, echinoderms, (fusulinids, bryozoans, gastropods)

Locality 7 (NQEB), New quarry east of Buffalo

NE ¼. NE ¼, sec. 22, T27S, R16E; quarry south of Kansas Highway 39 on north wall of quarry by ramp.

Captain Creek Ls.

L (- 6 ft.); skeletal calcilutite with brachiopods, bryozoans, algae, echinoderms, (foraminifera, ostracodes, fish elements, gastropods)

M (- 3 ft.); mottled skeletal calcilutite with algae, brachiopods, bryozoans, (foraminifera, fish elements, gastropods, sponges)

T; darker mottled skeletal calcilutite with calcarenite zones, bryozoans, brachiopods, (algae, echinoderms, ostracodes, foraminifera, sponges, fish elements)

Eudora Sh.

B; 4 in. thick fossiliferous dark gray shale with phosphate nodules, echinoderms, fish elements, orbiculoid brachiopods, (brachiopods, glauconite, bryozoans, quartz)

Stoner Ls. with interbedded shale

B; skeletal calcarenite with fine calcarenitic matrix, echinoderms, brachiopods, bryozoans, (bivalves, fish elements, ostracodes, coelenterates, glauconite). No evidence of cross bedding and fossils mainly whole shells and fronds.

1 (+ 1¼ ft.); skeletal calcarenite with some mud in geopetal fabric, echinoderms, brachiopods, bryozoans, (bivalves, fish, foraminifera), gastropods. No evidence of cross bedding and fossils mainly whole shells and fronds.

2 (+ 1½ ft.); fossiliferous gray shale with bryozoans, brachiopods, echinoderms, (spirorbids, foraminifera, ostracodes, quartz, fish elements)

3 (+ 3½ ft.); skeletal calcilutite with brachiopods, bryozoans, foraminifera, echinoderms, (algae, fish elements, spirorbids)

5 (+ 5 ft.); fossiliferous gray shale with bryozoans, brachiopods, echinoderms, spirorbids, ostracodes, foraminifera, (fish elements, bivalves, gastropods)

U (+ 8 ft.); skeletal calcilutite with bryozoans, echinoderms, algae, brachiopods, foraminifera, (sponges)

Locality 8 (RCESLQ), Roadcut east of Wilson County State Lake Quarry

SE ¼, sec. 16, T27S, R16E; roadcut on north side of Kansas Highway 39.

Stoner Ls.

4 (- 4 ft.); muddy skeletal calcarenite with bryozoans, brachiopods, echinoderms, (sponges, foraminifera). Probably contains algal blades, many collapsed.

1 (- 1 ft.); mottled skeletal calcilutite with bryozoans, (echinoderms, algae, brachiopods)

T; skeletal calcilutite with abundant small non-descript skeletal fragments, bryozoans, echinoderms, brachiopods, (fish elements, sponges)

Rock Lake Sh.

L; 1 ft. thick sandy light gray shale with bryozoans, echinoderms, quartz, (fish elements)

Locality 9 (TSBB), Type Section of Benedict Bed

NW ¼. NW ¼, sec. 11, T28S, R15E; roadcut on east side of road north of Benedict.

Vilas Sh.

T; gray shale with ostracodes (echinoderms, gastropods, oolites, sponges, brachiopods)

Benedict Bed

B; spar-cemented ooid calcarenite with brachiopods, (algae, interclasts, gastropods, bryozoans, ostracodes, fish elements). Some of the larger shells are oolitically coated.

T (+ 4½ ft.), spar-cemented ooid calcarenite with brachiopods, algae, (gastropods, bryozoans, bivalves, ostracodes, fusulinids, fish elements)

Captain Creek Sh.

B; fossiliferous tan shale with oolites, echinoderms, ostracodes, brachiopods, bryozoans, (spirorbids, sponges, fish elements)

T (+ 2½ ft.); fossiliferous tan shale with echinoderms, bryozoans, ostracodes, spirorbids, (brachiopods, sponges, bivalves)

Captain Creek Ls.

B; whole shell skeletal calcarenite with calcilutite patches possibly under former algal blades, brachiopods, algal crusts and blades, (echinoderms, ostracodes, foraminifera, bryozoans, fish elements, pellets, some smaller skeletal fragments may be coated)

Locality 10 (BB), Benedict Bridge, Flank of algal buildup

NE ¼. NE ¼, sec. 16, T28S, R15E; outcrop along south side of Verdigris River at Benedict Bridge.

Stoner Ls.

M (- 3 ft. from Stoner - U); mottled skeletal calcilutite to muddy calcarenite with bryozoans, echinoderms, brachiopods, (bivalves, ostracodes, gastropods, foraminifera, fish elements)

U; muddy skeletal calcarenite with echinoderms, bryozoans, brachiopods, (ostracodes, gastropods, foraminifera, fish elements)

Locality 11 (5a), Field trip stop 5a; (ACN), Altoona cut north

SW ¼, sec. 7, T29S, R16E; roadcut north of locality 12 on east side of gravel road.

Vilas Sh.

T; unfossiliferous gray shale

Captain Creek Ls.

B; darker mottled skeletal calcilutite with brachiopods, echinoderms, (algae, foraminifera)

U (+ 12 ft.); skeletal calcilutite with algae, bryozoans, brachiopods, (echinoderms, foraminifera, gastropods)

Stoner Ls.

B; muddy skeletal calcarenite with brachiopods, echinoderms, bryozoans, (algae, ostracodes, gastropods, fish elements, foraminifera, orbiculoid brachiopods, quartz crystals, glauconite)

M (+ 3 - 5 ft.); skeletal calcilutite with fine non-descript calcarenite debris, bryozoans, echinoderms, brachiopods, (fish elements, foraminifera)

Locality 12a (ARC), Altoona roadcut

NE ¼, sec. 18, T29S, R16E; roadcut on south side of Kansas Highway 47.

Captain Creek Ls.

B; mottled skeletal calcilutite with most skeletal fragments unidentifiable, (probable algae, brachiopods, echinoderms, bivalves, bryozoans, fish elements, coelenterates, sponges, foraminifera)

Locality 12b (ARC), Altoona roadcut

NE $\frac{1}{4}$, sec. 18, T29S, R16E; roadcut on north side of Kansas Highway 47 at base of channel.

Captain Creek Ls.

T (+ 3 - 5 ft.); skeletal calcilutite to muddy calcarenite with bryozoans, (brachiopods, fish elements, echinoderms, algae, foraminifera, gastropods, coelenterates)

Eudora Sh.

B; 2 in. thick fossiliferous tan shale with gastropods, brachiopods, bryozoans, (echinoderms, ostracodes, fish elements, fusulinids)

1; 2 in. thick dark shaly skeletal calcilutite with brachiopods, (echinoderms, ostracodes, gastropods, fish elements, quartz, glauconite)

2; 6 in. platy black shale with orbiculoid brachiopods, (brachiopods, echinoderms, fish elements, bryozoans, gastropods)

T; 4 in. thick fossiliferous gray shale with echinoderms, bryozoans, brachiopods, (orbiculoid brachiopods, fish elements, phosphate nodules, gastropods)

Stoner Ls.

B; skeletal calcilutite with abundant small skeletal debris with bryozoans, echinoderms, brachiopods, (fish elements, quartz crystals, glauconite)

U (+ 11 ft.); muddy skeletal calcarenite with brachiopods, echinoderms, bryozoans, probable algal blades, (fish elements, gastropods)

Locality 12C (ACW), Altoona cut west

NW ¼, sec. 18, T29S, R16E; quarry on south side of Kansas Highway 47 west of locality 12a.

South Bend Ls.

L; calcarenite quartz sandstone, oolites, abraded brachiopod fragments, (fish elements, bryozoans, sponges, orbiculoid brachiopods)

Locality 13 (WN), West of Neodesha

SW ¼. SW ¼, sec. 22, T30S, R15E; roadcut on north side of Kansas Highway 96.

Stoner Ls.

U (- 2 in.); skeletal calcilutite with algae, foraminifera, (brachiopods, bryozoans, echinoderms, ostracodes)

T; skeletal calcilutite with brachiopods, bryozoans, (algae, foraminifera)

Locality 14 (RC), Elk City Dam Roadcut

NW ¼, sec. 7, T32S, R15E; roadcut on north side of road with channel outcrop on south side of road.

Vilas Sh.

T; gray shale with echinoderms, bryozoans, (ostracodes, foraminifera, brachiopods, gypsum)

Captain Creek Ls.

B; skeletal calcilutite with algae, brachiopods, echinoderms, bryozoans, sponges, foraminifera, (fusulinids, spirorbids, fish elements)

T (+ 41 ft.); mottled skeletal calcilutite with former algal blades sheltering voids, brachiopods, (echinoderms, bryozoans, fusulinids, ostracodes, foraminifera)

Stoner Ls. Channel (C)

C - L; skeletal calcarenite with echinoderms, (brachiopods, fusulinids, bryozoans, foraminifera, fish elements, some limonite in matrix)

C - M (+ 5 ft.); muddy skeletal calcarenite with bryozoans, echinoderms, brachiopods, (fusulinids, fish elements, foraminifera)

C - U (+ 10 ft.); muddy skeletal calcarenite with echinoderms, fusulinids, bryozoans, (brachiopods, foraminifera)

Stoner Ls. with Interbedded Sh.

L (- 30 ft.); muddy skeletal calcarenite with echinoderms, brachiopods, bryozoans, fusulinids, (foraminifera, gastropods)

T (- 20 ft.); fossiliferous gray shale with brachiopods, bryozoans, (echinoderms, ostracodes, foraminifera, fusulinids, orbiculoid brachiopods)

Stoner Ls.

B (- 20 ft.); muddy skeletal calcarenite with echinoderms, bryozoans, brachiopods, foraminifera, probable algal blades, (fusulinids, fish elements, gastropods)

T; skeletal calcilutite with algae, brachiopods, echinoderms, bryozoans, (foraminifera)

Rock Lake Sh.

B; tan shale, fossils rare, quartz

M (+ 2 ft.); tan shale, fossils rare, quartz

T (+ 6 ft.); tan shale, fossils rare, quartz

South Bend Ls.

T (+ 18 ft.); skeletal calcilutite with echinoderms, (brachiopods, fusulinids, algae, fish elements, foraminifera)

Locality 15 (ECQ), Elk City Quarry

NW ¼. SW ¼, sec. 17, T32S, R14E; east side of quarry west of U.S. Highway 160.

South Bend Ls.

U (- 2 in.); skeletal calcilutite with echinoderms, bryozoans, brachiopods, fusulinids, (sponges, foraminifera, algae, fish elements)

T; skeletal calcilutite with echinoderms, fusulinids, brachiopods, (sponges, fish elements, foraminifera, algae)

Weston Sh.

B; fossiliferous tan shale with echinoderms, brachiopods, bryozoans, fusulinids, ostracodes, foraminifera, (fish elements, holothurian elements)

Locality 16 (THE), Timber Hill East

NW $\frac{1}{4}$. NW $\frac{1}{4}$, sec. 25, T32S, R14E; roadcut on both sides of road.

Eudora Sh.

L (- 8 ft.); gray shale with snails, bivalves, ostracodes, foraminifera, (echinoderms, bryozoans, scaphopods, brachiopods)

M (- 4 ft.); gray shale with snails, bivalves, ostracodes, echinoderms, (foraminifera, holothurian elements, bryozoans, scaphopods)

T; tan shales, fossils rare, quartz, (ostracodes)

Rock Lake Sh.

B; unfossiliferous tan shale

M (+ 4 ft.); unfossiliferous tan shale

T (+ 8 ft.); unfossiliferous gray shale with quartz

South Bend Ls.

T (+ 6$\frac{1}{2}$ ft.); skeletal calcilutite with brachiopods, bryozoans, echinoderms, (algae, gastropods, foraminifera, fish elements)

Locality 17a (EUS160RC), East of U.S. Highway 160 Roadcut

NW $\frac{1}{4}$. NE $\frac{1}{4}$, sec. 36, T32S, R14E; roadcut on north side of U.S. Highway 160.

Vilas Sh.

T; fossiliferous tan shale with echinoderms, brachiopods, (bryozoans, ostracodes, foraminifera)

Captain Creek Ls.

B; skeletal calcilutite with echinoderms, (coelenterates, algae, bryozoans, brachiopods, fusulinids, sponges, quartz)

Locality 17b (US160RC), U.S. Highway 160 roadcut; (14a), Heckel's section 14a

NW $\frac{1}{4}$. NW $\frac{1}{4}$, sec. 36, T32S, R14E; roadcut on north side of U.S. Highway 160.

Eudora Sh.

L (- 15$\frac{1}{2}$ ft.); fossiliferous gray shale with echinoderms, gastropods, bivalves, foraminifera, ostracodes, (bryozoans, scaphopods)

11 (- 11$\frac{1}{2}$ ft.); fossiliferous gray shale with foraminifera, echinoderms, gastropods, bivalves, ostracodes, (holothurian elements)

8 (- 8$\frac{1}{2}$ ft.); fossiliferous gray shale with foraminifera, echinoderms, ostracodes, (gastropods, bivalves, holothurian elements, scolecodonts)

3 (- 3 ft.); fossiliferous gray shale with echinoderms, brachiopods, bryozoans, foraminifera, ostracodes, (holothurian elements)

T; gray shale with silt, (echinoderms, ostracodes, foraminifera, holothurian elements)

Rock Lake Sh.

B (7 ft.); tan shale with silt, (ostracodes, foraminifera, echinoderms)

T; tan shale, fossils rare, quartz, (carbonized plants)

Locality 18 (RB), Rutland Bed

SW ¼. SW ¼, sec. 36, T32S, R14E; west side of small quarry on east side of gravel road.

Rutland Bed

L (- 3 ft.); skeletal calcarenite with algae, brachiopods, fusulinids, bryozoans, echinoderms

U; skeletal calcarenite with algae, brachiopods, bryozoans, echinoderms, (fusulinids, gastropods, foraminifera, carbonized plants, quartz crystals)

Locality 19 (WM), Walker Mound

NE ¼. NE ¼, sec. 5, T33S, R15E; road ditch on south side of road.

Vilas Sh.

T; tan shale with quartz, (echinoderms, bryozoans, oolites, bivlaves, ostracodes)

Captain Creek Ls. with interbedded shale

B; 2 in. thick oolitic calcarenite with (echinoderms, brachiopods, bryozoans, bivalves, fish elements, gastropods). Some skeletal grains oolitically coated.

1 (+ 2 in.); fossiliferous gray shale with sponges, echinoderms, bryozoans, brachiopods, (oolites, quartz, fusulinids, ostracodes)

5 (+ 5 ft.); fossiliferous gray shale with sponges, echinoderms, brachiopods, bryozoans, (spirorbids, ostracodes, foraminifera, bivalves, arthropods)

6 (+ 5½ ft.); skeletal calcilutite with algae, sponges, bryozoans, brachiopods, echinoderms, (foraminifera, fish elements)

Eudora Sh.

B; 2 ft. thick fossiliferous gray shale with echinoderms, brachiopods, bryozoans, (fish elements, ostracodes, foraminifera, orbiculoid brachiopods, holothurian elements, arthropods, coelenterates, bivalves)

2 (+ 2 ft.); lower 6 in. of 2 to 3 ft. thick platy black shale with (fish elements, phosphate, orbiculoid brachiopods)

4 (+ 4 - 5 ft.); bedding plane samples on black platy shale with (orbiculoid brachiopods, phosphate, fish elements)

20 (+ 20 ft.); fossiliferous gray shale with echinoderms, brachiopods, foraminifera, ostracodes, bryozoans, gastropods, (fish elements, bivalves, holothurian elements, spirorbids)

Locality 20 (#27), Heckel's Section 27; (RR), Railroad cut

NW ¼, sec. 36, T33S, R14E; roadcut and railroad cut along west side of U.S. Highway 75.

Vilas Sh.

T; fossiliferous tan shale with brachiopods, echinoderms, bryozoans, (sponges, foraminifera, gastropods)

Captain Creek Ls.

B; skeletal calcilutite with sponges, echinoderms, brachiopods, bryozoans, (foraminifera)

U (+ ½ ft.); skeletal calcilutite with brachiopods, foraminifera, echinoderms, bryozoans, sponges, (algae?, gastropods, ostracodes)

Bolton Bed

B; muddy skeletal calcarenite with calcilutite zones, echinoderms, brachiopods, (bryozoans, ostracodes, oolites, sponges, gastropods, foraminifera)

M (+ 21 in.); skeletal calcarenite with brachiopods, echinoderms, bryozoans, (ostracodes, gastropods, foraminifera)

T (+ 3½ ft.); skeletal calcilutite with brachiopods, echinoderms, bryozoans, (gastropods, foraminifera, ammonoids, sponges)

Rock Lake Sh.

B; fossiliferous tan shale with brachiopods, bryozoans, echinoderms, ostracodes, foraminifera, (gastropods, fish elements)

U (+ 1½ ft.); fossiliferous tan shale with brachiopods, echinoderms, bryozoans, ostracodes, (quartz, coelenterates, fish elements)

Locality 21 (#30), Heckel's Section 30; (BH), Brook's Hill

SW ¼. SW ¼, sec. 31, T33S, R15E; roadcut on north side of road.

Eudora Sh.

M (- 5 ft.); tan shale with (foraminifera, echinoderms, gastropods, bivalves, (ostracodes)

T; tan shale with (foraminifera, oolites, brachiopods, quartz, gastropods, ostracodes)

Bolton Bed

B; skeletal calcilutite with an oolite zone, brachiopods, echinoderms, (bryozoans, sponges, gastropods, ostracodes, foraminifera, bivalves)

Locality 22 (RCWHWJ), Roadcut West of Hill West of Jefferson

NE ¼. SW ¼, sec. 6, T34S, R15E; road ditch on both sides of gravel road.

Tyro Oolite

T; oolites with (echinoderms, gastropods)

Eudora Sh.

B; fossiliferous gray shale with bryozoans, echinoderms, oolites, (brachiopods, ostracodes, spirorbids, quartz)

5 (+ 5 ft.); fossiliferous gray shale with bryozoans, brachiopods, echinoderms, ostracodes, foraminifera, quartz, oolites, spirorbids, sponges, holothurian elements, gastropods)

6 (+ 6 ft.); 2 ft. thick platy black shale with phosphate nodules, foraminifera, quartz, (orbiculoid brachiopods, fish elements)

7 (+ 7 ft.); fossiliferous gray shale with quartz, foraminifera, echinoderms, gastropods, brachiopods, (ostracodes, bivalves, oolites)

T (+ 14 ft.); fossiliferous gray shale with quartz, foraminifera, echinoderms, ostracodes, (brachiopods, gastropods, ammonoids, nautiloids, holothurian elements)

Bolton Bed

B; muddy skeletal calcarenite with brachiopods, echinoderms, bryozoans, (ostracodes, oolites, gastropods, fish elements, bivalves)

Locality 23 (SBWW), South Bend West of Wayside

NW ¼. SW ¼, T34S, R14E; road ditch south of U.S. Highway 75.

Rock Lake Sh.

T; gray shale with quartz, echinoderms, (brachiopods)

South Bend Ls.

U (+ 3 ft.); skeletal calcilutite with sponges, echinoderms, (brachiopods, bryozoans, coelenterates)

Locality 24 (TyQu), Tyro Quarry

SE $\frac{1}{4}$, sec. 30, T34S, R15E; south side of quarry.

Tyro Oolite

M (- 5 ft.); oolite with (echinoderms, brachiopods, gastropods)

T; calcilutite with scattered oolites, (echinoderms, brachiopods, sponges)

Eudora Sh.

B; 1 ft. thick fossiliferous gray shale with quartz, echinoderms, brachiopods, (bryozoans, ostracodes, bivalves)

T; 1 ft. thick fossiliferous platy dark gray shale with phosphate nodules toward base, quartz crystals, foraminifera, echinoderms, (brachiopods, ostracodes, nautiloids, ammonoids, bryozoans, gastropods, bivalves, fish elements, scolecodonts)

Eudora/Rock Lake Sh.

5 (+ 5 ft. from Eudora base); unfossiliferous gray shale with silt, (quartz, carbonized plants)

8 (+ 8 ft. from Eudora base); unfossiliferous gray shale with silt, (quartz, carbonized plants)